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HOW WE TEACH | *Generalizable Education Research*

Flipped classroom narrows the performance gap between low- and high-performing dental students in physiology

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Xiao N, Thor D, Zheng M, Baek J, Kim G. Flipped classroom narrows the performance gap between low- and high-performing dental students in physiology. *Adv Physiol Educ* 42: 586–592, 2018; doi:10.1152/advan.00104.2018.—The flipped classroom has been shown to have positive outcomes in learning. However, relatively little has been reported on the implementation of it in dental education. The purpose of this study was to evaluate the impact of the flipped classroom on predoctoral dental students' learning. Two consecutive classes of dental students learned the physiology of the autonomic nervous system through the nonflipped (traditional lecture) or the flipped approach. Students' learning was assessed with an identical quiz at the end of the module. The mean score in the flipped approach was higher than that in the nonflipped approach ($P < 0.01$). Mean score on the content-based quiz questions in the flipped approach was higher than that in the nonflipped approach ($P < 0.05$). Performance on case-based questions did not show a significant difference ($P = 0.12$). Mean quiz performance of the lower 27% scorers in the flipped approach was higher than that in the nonflipped approach ($P < 0.05$). Mean quiz performance of the upper 27% scorers showed an increase in the flipped approach as well ($P < 0.05$), but to a less extent than that of the lower 27% scorers ($P < 0.01$). The flipped approach also increased peer collaboration ($P < 0.01$). In summary, the flipped classroom improved dental students' performance on content-based questions in physiology. The flipped classroom narrowed the performance gap between the low- and high-performing dental students.

autonomic nervous system; biomedical science; dental students; flipped classroom; physiology

INTRODUCTION

The ability to apply basic sciences in clinical practice is essential to dental students. According to the Accreditation Standards For Dental Education Programs by Commission On Dental Accreditation, "Graduates must be competent in the application of biomedical science knowledge in the delivery of patient care" (6). Traditionally, the teaching of basic sciences in many dental schools has been in large-sized lectures. Although lecture is an efficient way to convey a large amount of information to a large group of students, teacher-centered lectures have been criticized for failing to engage students and develop the higher level cognitive skills (10, 28). Additionally, basic science faculties in dental school have been facing the challenge of a very intensive and crowded curriculum (29). There is a large amount of biomedical science content to be covered within a limited amount of classroom instruction time. Dental educators and policy makers have made repeated calls to move away from one-way information dissemination that is often found in traditional lectures (12). In this context, a growing number of dental faculties have started to explore alternative delivery approaches.

The flipped classroom is an example of student-centered instructional approaches that has gained considerable attention in health sciences education. It is an instructional approach in which foundational knowledge is delivered online for students to study at their own pace, and class time is devoted to active learning activities to deepen students' comprehension of the content (2). The goal is to make learning more student centered and to promote the development of higher level learning outcomes on Bloom's taxonomy (17).

There is some evidence suggesting that the flipped classroom is at least as effective as, and in some cases more effective than, traditional lectures in promoting student learning in the health sciences. Tune and colleagues (27) found that the flipped classroom model significantly improved students' quiz performance in a medical physiology course. Pierce and Fox (23) reported that pharmacy students who received instruction in the flipped classroom format performed significantly better in the final exam than students of the previous year who received instruction in the lecture format. Similarly, Missildine et al. (18) reported that nursing students participating in a flipped nursing pharmacology course achieved significantly higher exam scores compared with those undertaking traditional lectures.

Despite the increasing adoption of the flipped classroom in dental education, research on its implementation and outcomes is still limited. Additionally, conflicting results are often reported. Park and Howell (21) found that the flipped classroom increased dental students' participation and interaction in the class. Bohaty and colleagues (3) flipped a pediatric dentistry course and found that the number of students who received an A course grade was significantly higher than in the previous year when the course was taught in a lecture format. Conversely, faculty at Harvard University showed that dental students in the flipped classroom approach achieved higher tooth waxing scores than those in the lecture approach. However, no significant difference was found in students' end-of-

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course grade (5). Nishigawa and colleagues (20) compared the impact of team-based learning and the flipped classroom on dental students' end-of-term exam scores in a fixed prosthodontic course. The researchers found no significant differences in students' exam scores based on the two different instructional models. The conflicting results indicated that existing evidence is insufficient to confirm the effectiveness of the flipped classroom in dental education. More research in this field is warranted.

In an effort to promote student-centered learning and the application of basic science knowledge in patient care, we redesigned a module on the autonomic nervous system (ANS) from a face-to-face traditional lecture in a physiology course taught to first-year dental students into a flipped learning experience. The aim of this study was to compare student learning of the ANS via the flipped classroom approach or the nonflipped traditional lecture approach. We assessed student performance on content-based and case-based quiz questions in the flipped and nonflipped approach. We also examined the effectiveness of the flipped classroom for learning in low- and high-performing students and the voluntary peer collaboration, areas that have rarely been investigated in existing studies.

METHODS

Ethical statement. The University of the Pacific's institutional review board approved this study (proposal no. 17-83).

Participants. Two consecutive classes of students in their first year of the 3-yr Doctor of Dental Surgery (DDS) program at the Arthur A. Dugoni School of Dentistry, University of the Pacific, participated in this study in 2016 and 2017. The mean grade point average (GPA) (DDS2019: 3.48, DDS2020: 3.50, using a 4-point scale) and dental admission test (DAT) (DDS2019: 21.09, DDS2020: 21.50, with 17 typically signifying average performance) scores were comparable between the two classes. The dental school runs on a quarter system, and ANS is a module in the Physiology course that runs across three quarters. This module has a 3-h lecture time and took place at the end of the first quarter. One hundred and forty-two students received instruction on ANS in the nonflipped traditional lecture format. One hundred and forty-one students received the same content in the flipped classroom approach.

Study design. We implemented a comparative design. Figure 1 showed the schematic diagram of the study. The lecture slides were identical for both classes of students. Learning materials and instruction were accessible to students on the school's learning management system. The nonflipped and flipped approach each took approximately 2.5 h.

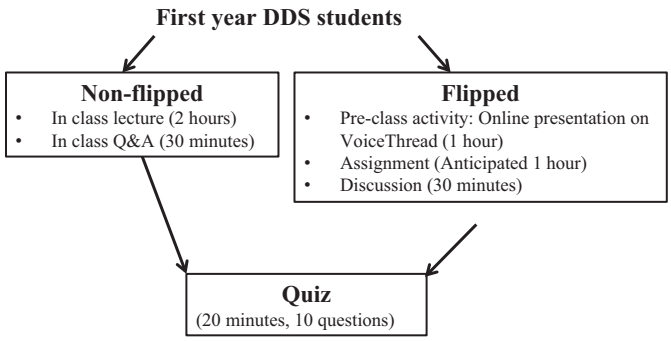


Fig. 1. Schematic diagram of the nonflipped and flipped approach design. Important features included in the nonflipped and flipped module are shown. DDS, Doctor of Dental Surgery; Q&A, question and answer.

In the nonflipped approach, students received a 2-h lecture in the classroom, followed by a 30-min question-and-answer session. The lecture was video captured and uploaded on the school's learning management system.

In the flipped approach, students self-studied an online module, which was a 1-h presentation delivered by the same faculty. The online tool VoiceThread allowed instructors to upload presentation slides and record audio narration for each slide. It also allowed students to post comments and questions on the slides. Step-by-step tutorials on how to use VoiceThread were provided to the students. After studying the online module, students needed to finish an assignment composed of three content-based questions and two cases related to the application of ANS in clinical practice, each with a couple of open-ended questions. The assignment was homework. One hour of lecture time was given away, and the instructor anticipated that 1 h would be sufficient to finish the assignment. Students did not have to turn in the assignment. There was no specification on whether the students needed to work on the assignment alone or as a group. There was a 30-min discussion of the assigned questions and cases in the classroom. The assignment can be found in APPENDIX A.

Quiz data collection. Students in the nonflipped and the flipped classes took an identical quiz developed by the instructor for the ANS module at the end of the module. The quiz was not returned to students, to keep the content of the quiz confidential. The quiz consisted of 10 multiple-choice questions. Six of them tested students' understanding of foundational content. The other four questions were case based and tested students' application of foundational knowledge. The assignment can be found in APPENDIX B. Taking the quiz was voluntary, and students received 0.5 bonus point per correct answer. The bonus points were added as extra points to the student's total score at the end of the course to calculate the final grade.

Students took the quiz through Examsoft, a computer-based testing system. The testing software provided data on students' average performance on the quiz and on each question. It also identified the upper 27% and lower 27% of the class on the quiz. The upper and lower index reflected what percentage of the upper 27% or the lower 27% of scorers answered the question correctly. 27% is an industry standard by default in Examsoft in item analyses. For the purpose of data analysis in our study, the upper 27% of students were considered high-performing students, and the lower 27% were considered low-performing students.

Data analysis. Data were presented as means (SD). Mean scores on all questions, on content and case-based questions, among the upper 27% and lower 27% performing students were compared between the nonflipped and flipped approach. Student's *t*-tests (2-tailed) were used to compare the data. $P \leq 0.05$ is considered to be significant.

We also analyzed and compared the number of students who reported studying in groups or alone in the nonflipped and the flipped approach. A χ^2 test was used. $P \leq 0.05$ is considered to be significant.

RESULTS

Flipped approach improved students' average quiz performance. There were 133 (response rate 94%) and 141 students (response rate 100%) who took the quiz for the nonflipped approach and flipped approach, respectively. The quiz results indicated that the flipped classroom enhanced students' learning of ANS in physiology. The highest quiz score for both the nonflipped and flipped classes was 100%. The lowest score was 10% for the nonflipped approach and 40% for the flipped approach (Fig. 2*A*). Statistical analysis showed that the mean quiz score of students in the flipped approach [80% (SD 19)] was significantly higher than that of students in the nonflipped approach [69% (SD 23), $P < 0.01$] (Fig. 2*B*). Additionally, 94 students in the flipped approach

A

	Non-flipped Approach	Flipped Approach
Number of Students	142	141
Number of Quiz Taker	133	141
Response rate	94%	100%
Number of Questions	10	10
Average Score (%)	69%	80%
Lowest Score (%)	10%	40%
Highest Score (%)	100%	100%

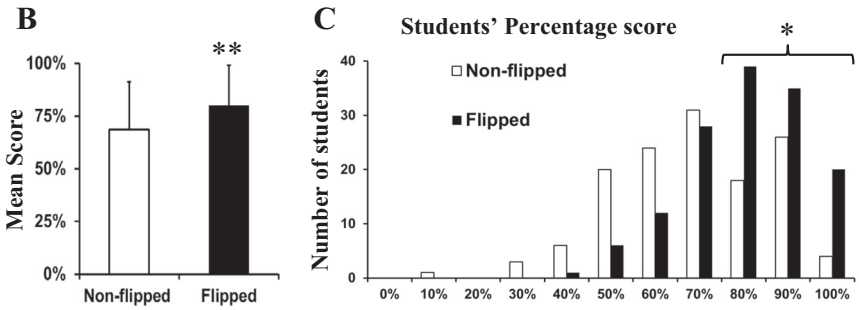


Fig. 2. Quiz performance of students in nonflipped and flipped approaches. *A*: the demographic features of students and the score range in the nonflipped and flipped approaches. *B*: mean (SD) score of students in the two instructional approaches (**$P < 0.01$). *C*: breakdown of student performance in the two approaches. The number of students who scored ≥80% in the flipped approach was significantly more than that in the nonflipped approach (*$P < 0.05$).

scored 80% or above. Only 48 students in the nonflipped approach scored 80% or above ($P < 0.05$) (Fig. 2*C*).

Flipped approach improved students' performance on content-based questions. We compared students' average performances on different types of questions between the flipped approach and the nonflipped approach. Mean score of students on the six content-based questions in the flipped approach [83% (SD 21)] was significantly higher than that in the nonflipped approach [73% (SD 23), $P < 0.05$]. Mean score on the four case-based questions showed a similar pattern of increase in the flipped approach [76% (SD 18)] compared with the nonflipped approach [63% (SD 23)], although the result was not statistically significant ($P = 0.12$). The mean score increased 10% on the six content-based questions, and 13% on the four case-based questions (Fig. 3*A*).

The breakdown of content-based and case-based questions showed that students performed better in the flipped approach than in the nonflipped approach, on average. The increases for

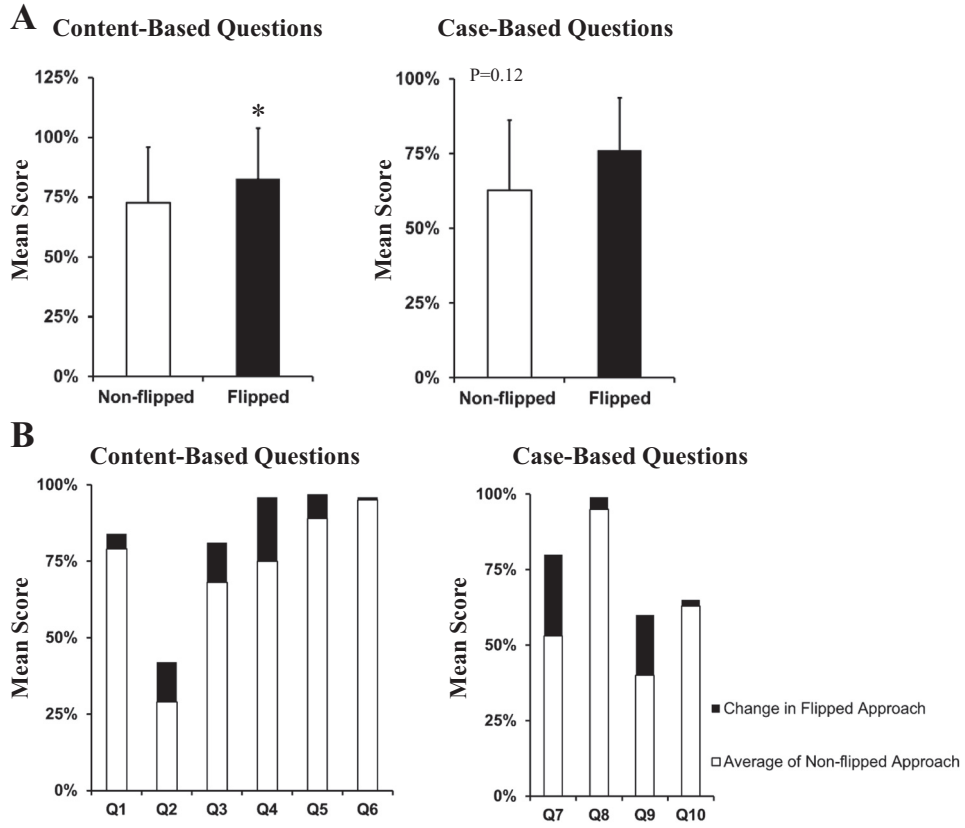


Fig. 3. Quiz performance of students on content and case-based questions. *A*: mean (SD) score of students on the six content-based questions and four cased-based questions in the nonflipped and flipped approaches (*$P < 0.05$). *B*: breakdown of student performance on content and case-based questions (Q). The open bars indicate the mean score in the nonflipped approach. The solid bars indicate the change of the mean score in the flipped approach compared with that in the nonflipped approach.

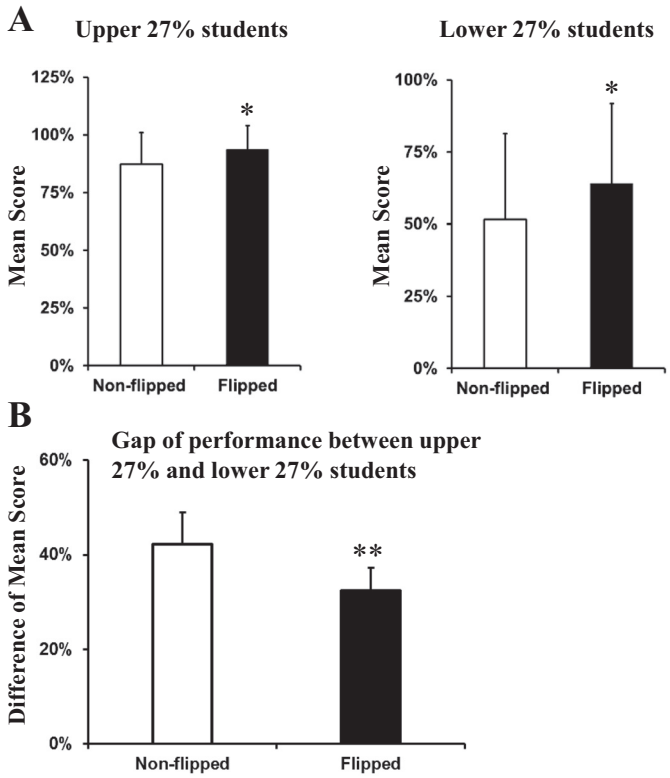


Fig. 4. Quiz performance of the low- and high-performing students. *A*: mean (SD) score of both the upper 27% and the lower 27% scorers significantly increased in the flipped approach (*$P < 0.05$). *B*: difference of mean score between the upper 27% and the lower 27% scorers in the flipped approach was significantly smaller than in the nonflipped approach (**$P < 0.01$).

content-based questions Q1 through Q6 were 5, 13, 13, 21, 8, and 1%, respectively. The increases for case-based questions Q7 through Q10 were 27, 4, 20, and 2%, respectively (Fig. 3*B*).

Flipped approach narrowed the performance gap between low- and high-performing students. We analyzed the mean score of the top 27% and bottom 27% of scorers on the quiz, to determine which group of students benefited more from the flipped approach. Both groups of students made a significant improvement on the quiz through the flipped approach than the nonflipped approach. Mean quiz performance of the upper 27% scorers in the flipped approach [94% (SD 10)] was significantly higher than that of the upper 27% scorers in the nonflipped approach [87% (SD 14), $P < 0.05$]. For the lower 27% scorers, the mean quiz performance was 64% (SD 28) in the flipped approach and 52% (SD 30) ($P < 0.05$) in the nonflipped approach. On average, the low-performing students made an increase of 12%, and the high-performing students made an increase of 7% in the flipped approach compared with in the nonflipped approach (Fig. 4*A*).

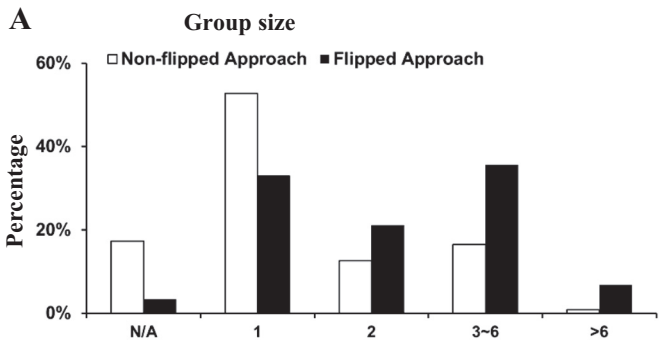
The improvement was significantly higher in students from the lower 27%. The gap of mean score between the upper 27% and the lower 27% students was 42.2% in the nonflipped approach. The gap reduced to 32.3% in the flipped approach (Fig. 4*B*).

Flipped approach promoted peer collaboration. We compared the number of students who studied the ANS module with peers between the flipped approach and the nonflipped approach to evaluate the impact of the flipped classroom on peer collaboration. There were 127 students (responding rate 89%) who took the traditional lectures in the nonflipped approach, and 118 students (responding rate 84%) who took the flipped classroom approach who responded to the question. The breakdown of the group size indicated that students preferred to study as a group in the flipped approach compared with in the nonflipped approach. The percentages of students who did not study at all (not applicable), studied alone (group size 1), with one other student (group size 2), with two to five other students (group size 3–6), and with more than five other students (group size >6) were 17.3, 52.8, 12.6, 16.5, and 0.8%, respectively, in the nonflipped approach. The percentages for the same size of study groups were 3.4, 33.1, 21.2, 35.6, and 6.8%, respectively, in the flipped approach (Fig. 5*A*).

A χ^2 test showed significant difference in the number of students who studied alone or as a group between the nonflipped and the flipped approach ($P < 0.01$). The numbers in the parentheses showed the expected number for each category (Fig. 5*B*).

DISCUSSION

Benefits of the flipped classroom. In this study, we reported the design, implementation, and outcomes of a flipped module on ANS in the physiology course offered to first-year predoctoral dental students. Consistent with some previous studies (11, 18, 23, 27), our data showed that the flipped classroom significantly improved the average performance of students. Moreover, the data indicated that the flipped approach significantly improved students' performance on content-based questions. Jensen et al. (14) reported that active learning was a



B

	Non-flipped Approach	Flipped Approach	Row Total
Alone (1)	67 (50.82)	39 (55.18)	106
Group (2 and above)	38 (54.18)	75 (58.82)	113
Column Total	105	114	219

The numbers in the parentheses showed the expected number for each category.

Chi-square test p<0.01

Fig. 5. Peer collaboration in nonflipped and flipped approaches. *A*: breakdown of the percentage of students in different-sized study groups in the nonflipped and flipped approaches. N/A, did not study before the quiz; 1, studied alone; 2, studied with one other person; 3~6, studied with 2–5 people together; >6, studied with >5 people together. *B*: contingency table showing the observed number of students who studied the autonomic nervous system alone or in groups in the nonflipped and flipped approaches. χ^2 test showed significant difference ($P < 0.01$). The numbers in the parentheses showed the expected number for each category.

critical factor that contributed to the learning gains in education. The active learning experience in our flipped approach might have contributed to students' increased performance on the content-based questions. The results were consistent with research by Persky and Pollack (22), which showed flipped classroom improved students' performance on content knowledge.

However, Morton and Colbert-Getz (19) reported that the flipped classroom primarily benefited students when an assessment required analysis of content, and it did not show a significant effect on knowledge-based questions. There was also a report indicating that the flipped classroom promoted students' performance by devoting more time for critical thinking (7). This would be one of the reasons for improved students' performance on case-based questions. We found the average students' performance increased 13% on the case-based questions in the flipped approach compared with the nonflipped approach. The increase was greater than that on the content-based questions (10%), but was not statistically significant. This might be because of the small number of case-based questions in our quiz.

Our study was novel in looking into the performance of high-performing and low-performing students through the flipped or nonflipped approach. This is an area that has received little attention. Our results indicated that, compared with the traditional lecture, the flipped approach helps to narrow the gap between the low-performing and high-performing students, when students received the same content through the flipped classroom. One possible reason was that the flipped approach increased the flexibility of learning and further engaged students in the learning process through self-paced study compared with traditional lecture. Khanova et al. (15) showed that students perceived the major advantage of a flipped pharmacotherapy course to be the increased flexibility. Similarly, Koo et al. (16) also found that students who struggled with the time requirement of the course were especially appreciative of the flexibility of the flipped design. The flexibility of the flipped approach allowed the low performers to access the lecture online at their convenience and at their own pace. Students were able to pause and check references on the topics on which they had questions, whereas the top performers might not heavily depend on this feature of flipped classroom.

We also found that the flipped approach improved peer collaboration among students. In our flipped approach, we did not require team learning to finish the assignment, but students chose to study in groups. Previous studies demonstrated that team-based learning had a favorable impact on student retention of material and was a critical component of the flipped classroom (21, 22). Survey results from Altintas et al. (1) showed that $>70\%$ of a total of 169 students felt that team-based learning enabled better understanding, was more interesting, ensured greater student participation, and involved greater effort on the part of students compared with the traditional lecture.

The increased peer collaboration in our flipped classroom might be another reason why students at risk made more improvement than high performers. Students at risk might benefit from working with high performers, or simply by being more engaged in the team learning. By asking questions, finding answers together, and explaining their understanding to others, group members could learn from each other.

Lessons learned in the flipped classroom module. We learned several important lessons from designing and teaching the flipped classroom module. Since it was the first time we did a flipped classroom on the subject, it took more time than preparing a traditional lecture. Instructors needed to record the lecture online, find the appropriate cases, write the questions that were pertinent to the learning objectives and the cases, and write detailed instructions to guide the students through the flipped classroom.

Students' self-directed learning might impact the outcomes of the flipped classroom. Survey on dental and medical students' use and perception of learning resources in a human physiology course showed that the greatest percentage of students still heavily depended on the guidance from the instructor, either in class or in flipped classroom sessions (26). In our flipped module, some students did not study the online materials. They also did not complete the assignment before the in-class question-and-answer session, although the percentage of these students was lower in the flipped approach (3.4%) than in the nonflipped approach (17.3%). It is important that students take personal responsibility for learning. As the instructor, we could teach students good time management skills. It is crucial to cultivate self-directed learning habits among students throughout the curriculum, so they can make the most out of the flipped classroom.

Another challenge we faced was reduced face-to-face contact compared with the in-class lecture. This is especially true for students who preferred to do the assignment by themselves; they potentially spent more time in front of the computer searching for the answers. The in-class discussion sessions partially compensate for the shortcoming. However, for a large class with over 140 students, it would be difficult to have every student be actively involved in the in-class discussion. It would require more faculty to split the class into small groups, which is not a realistic solution for now.

We were hoping the online discussion would be supplemental to the in-class discussion, but the online discussion lacked immediate feedback for the students, which was consistent with a previous report (8). Although VoiceThread allowed students to make comments and ask questions directly on the slides, students did not use this feature very often. One possible reason might be that the conversation on VoiceThread was asynchronous, and so there was delay in instructor responses to students' questions.

Finally, it took time to become familiar with the online learning system. Students' level of preparedness in online learning will influence the effectiveness of the flipped classroom (13). Rodriguez et al. (24) demonstrated that students' online learning experience played a role in their perceptions of flipped courses. Despite the written instructions, some students found VoiceThread hard to navigate, which might have negatively impacted their learning experience and impaired their engagement in the online and classroom discussion. In the future, we plan to give a live demonstration of VoiceThread in class and walk students through the tool to address potential technical challenges in the flipped classroom.

Limitations and future directions. Our study had several limitations. First, we used single-best-option, multiple-choice questions to evaluate the learning outcomes. Some researchers posit that the impact of the flipped classroom on students' content learning, as reflected in their test scores, was related to

the level of cognition required by the assessment items (19). Scouller (25) stated that multiple-choice questions were mainly used to assess knowledge-based information, whereas essays were associated with higher level cognitive activities. In the future, we would consider using different types of questions to further evaluate both lower and higher level learning outcomes from flipped classroom and traditional lectures.

Second, there were only 10 questions in the quiz, among which only 4 were case-based questions. It would be necessary to increase the number of questions, especially the case-based questions in the future to further evaluate the impact of the flipped classroom on critical thinking.

In addition, the study was conducted with two different classes across years. Although the average GPA and DAT scores were similar between the two classes in this study, it is difficult to control the variation of baseline knowledge in physiology among each individual. Students also had personal preferences on different pedagogical models. The interpersonal variation might have an impact on the effectiveness of the flipped classroom or the in class lecture.

Finally, we only compared the immediate impact of the flipped classroom and traditional lecture on students' quiz score at the end of the ANS module. A recent study showed that the flipped classroom improved students' performance in the semicumulative Gross Anatomy laboratory examination, but not the previous two intermediate examinations (9). As Chen et al. (4) stated, long-term evaluation of knowledge retention through the flipped classroom needs further investigation. Moving forward, we also plan to conduct longitudinal research to examine the impact of the flipped classroom on knowledge retention and application.

Conclusions. Taken together, the findings suggest that the flipped classroom approach was an effective pedagogical model to improve first-year dental students' performance in physiology. Basic sciences faculty at dental schools and other health sciences programs could consider implementing the flipped classroom to enhance student learning, promote active learning and peer collaboration, and narrow the learning gap between high-performing and low-performing students. Instructors should carefully design the online and in-class components of a flipped classroom module to engage students in the learning process and to promote self-directed learning and peer collaboration. This would maximize the positive impact of the flipped classroom on learning.

APPENDIX A: FLIPPED ANS ASSIGNMENT

1. Compare the sympathetic and the parasympathetic nervous systems.
2. Why is epinephrine commonly used with lidocaine together in dental analgesia?
3. When the sympathetic nervous system is activated, what is the effect on the artery and the arterioles, respectively? Why are the effects similar/different?
4. A 52-yr-old female patient Amy came to your office for her second appointment of a root canal treatment of tooth #30. She was diagnosed with hypertension 5 yr ago and has been taking prazosin and diuretics for management of hypertension. The patient's blood pressure was 115/69 mmHg and pulse was 58/min before the treatment. The procedure took about 60 min without any complication or complaint from the patient. When the patient returned to the upright posture, she complained of feeling nausea, dizzy, and having blurred vision. She was unable to stand up.
   - What is most likely the cause of the symptoms?
   - What should you do immediately?
   - What would you do in the future to prevent it from happening again?
5. A 64-yr-old man has spent much of the day working in the garden. A blustery wind caused him to unintentionally inhale the insecticide that he was spraying throughout the garden. When he started wheezing severely, he was taken to the emergency room. The physician observed constricted pupils and slowed heart rate. Patient was diagnosed with insecticide poisoning and treated with intravenous administration of atropine sulfate.
   - Insecticides contains organophosphates which inhibit acetylcholinesterase. Explain how the insecticide resulted in the patient's presenting symptoms.
   - What effect might the insecticide have on other organs and tissues?
   - Why is atropine an appropriate treatment for the patient?

APPENDIX B: ANS QUIZ

1. Acetylcholine binding to a nicotinic receptor produces a postsynaptic excitation. The initial most important postsynaptic ionic event generating this excitation is a(n) _____ conductance.
   A. decrease in Na^+
   ***B*. increase in Na^+**
   C. increase in Cl^-
   D. decrease in Cl^-
   E. (*B*) and (*D*)
2. A muscarinic receptor specific agonist would lead to _____ of the bronchioles. A β_1-adrenergic receptor specific antagonist would lead to _____ of the bronchioles.
   A. dilation; dilation
   B. constriction; constriction
   C. no effect; no effect
   D. constriction; dilation
   E. dilation; constriction
   ***F*. constriction; no effect**
3. Sympathetic stimulation leads to vasodilation mainly through _____ receptors on the arterioles.
   A. α_1 adrenergic
   B. α_2 adrenergic
   C. β_1 adrenergic
   ***D*. β_2 adrenergic**
   E. nicotinic
   F. muscarinic
4. Sympathetic stimulation leads to vasoconstriction mainly through _____ receptors on the arteries.
   ***A*. α_1 adrenergic**
   B. α_2 adrenergic
   C. β_1 adrenergic
   D. β_2 adrenergic
   E. nicotinic
   F. muscarinic
5. Epinephrine is most often synthesized from _____.
   A. histidine
   B. lysine
   C. alanine
   ***D*. tyrosine**
6. _____ is NOT an effector organ of the autonomic nervous system.
   ***A*. Skeletal muscle**
   B. Cardiac muscle
   C. Smooth muscle
   D. Excretory gland
7. When Amy complained about feeling nausea and dizzy and could not stand up after a root canal treatment, you found Amy's blood pressure (BP) dropped to 95/60 mmHg. You suspect that the drug Prazosin that

Amy has taken earlier is related to the drop of BP, because it is a _____.

A. α-adrenergic receptor agonist

***B*. α-adrenergic receptor antagonist**

C. β-adrenergic receptor agonist

D. nicotinic receptor agonist

E. muscarinic receptor antagonist

8. When Amy complained about feeling nausea and dizzy and could not stand up after a root canal treatment, which of the following is NOT the right thing to do?

***A*. Let Amy stand up immediately.**

B. Return Amy to semisupine position.

C. Monitor Amy's blood pressure and pulse.

D. Administer oxygen through nasal cannula to Amy.

E. All of the above are right to do.

9. Organophosphate insecticides inhibit acetylcholinesterase. Patient suffering from organophosphate poisoning would have _____ secretion from the salivary glands, and _____ muscle contraction in the digestive tract.

***A*. increased; increased**

B. increased; reduced

C. reduced; increased

D. reduced; reduced

10. Organophosphate insecticides inhibit acetylcholinesterase. Which of the following is/are affected by organophosphate poisoning?

A. Sympathetic postganglionic neuron

B. Parasympathetic postganglionic neuron

C. Cardiac muscle

D. Skeletal muscle

E. (*A*) (*B*) and (*C*)

***F*. (*A*) (*B*) (*C*) and (*D*)**

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DISCLOSURES

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

AUTHOR CONTRIBUTIONS

N.X., D.T., and M.Z. conceived and designed research; N.X., D.T., J.B., and G.K. performed experiments; N.X., D.T., J.B., and G.K. analyzed data; N.X., D.T., M.Z., J.B., and G.K. interpreted results of experiments; N.X. and D.T. prepared figures; N.X., D.T., and M.Z. drafted manuscript; N.X., D.T., and M.Z. edited and revised manuscript; N.X. approved final version of manuscript.

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