

## Article

# Student Preferences Impact Outcome of Flipped Classroom in Dental Education: Students Favoring Flipped Classroom Benefited More

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**Abstract:** Many reports in dental education showed that student learning improved with the flipped classroom method. However, there are few reports that describe how different subsets of students may benefit from the flipped classroom. In this study, we investigated how students' preference for the flipped classroom impacted their learning outcome. We used a flipped classroom module on the physiology of the autonomic nervous system taught to year one Doctor of Dental Surgery students to test the hypothesis that students who favored the flipped classroom performed better on assessment quizzes. The module was composed of pre-class activity, out-of-class assignment, in-class discussion, and two in-class quizzes. Quiz 1 was given after students self-studied the foundational content online through the pre-class activity, and Quiz 2 was at the end of the module. Students filled out a survey to report learning experiences and preferences. Fewer students scored below 75% on Quiz 2 than on Quiz 1. Students' self-evaluated understanding of content significantly improved after finishing the assignment and discussion compared to finishing the pre-class activity alone. Moreover, students who preferred to learn through the flipped classroom scored higher in Quiz 2. Students with higher overall grades in the course preferred the flipped classroom more than low performers. Our results indicated that students favoring the flipped classroom method spent more time on the assignment, understood the content better, and performed better on assessments than students who prefer traditional lectures.

**Keywords:** flipped classroom; physiology; dental education; learning preference



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## 1. Introduction

The flipped classroom is a pedagogical approach that reverses the sequence of teaching and learning of the traditional classroom. Essentially, students learn the instructional content in their own time before coming to class, while class time is used for other learning activities to enhance understanding and facilitate application [1]. The flipped classroom has been applied in college education and advocated in health profession education to promote student-centered learning, group learning, and critical thinking [2]. There are an increasing number of reports on the application of the flipped classroom in dental education [3].

The advances in digital technology and online resources can be used to capture the attention of students who are less engaged with traditional in-class lectures [4]. Nowadays, students prefer to learn by trial and error, learn through experience, and control the pace and sequence of learning [5,6]. They expect flexibility and efficiency in acquiring information [7]. The flipped classroom was viewed as a positive approach by Millennial students due to the combination of different learning opportunities [8].

Multiple factors contribute to the outcomes of a flipped classroom. Jensen and colleagues compared interactive reading tutorials with clickable questions and explanations,

video lectures and textbook-style readings for providing content materials in a flipped biology course for undergraduate students. They found video lectures offered a small advantage to students' performance in the final exam, possibly because it was easier for students to revisit the videos in preparation for the finals [9]. Shinaberger's study indicated that formative assessment and active learning that promoted peer–peer and peer–instructor interaction were important to improve students' performance in a flipped classroom [10]. Chuang et al. showed significant association between students' motivation and learning outcomes in a flipped classroom in an Applied English for Vocational Education course [11].

There are also barriers that impair the engagement of students in the flipped classroom. Jesurasa and colleagues reported that the design of the flipped classroom, such as the degree to which the classroom is flipped, the challenges to acquiring fundamental knowledge, limitation of larger class sizes, teaching styles, and students' expectation of the instructors, may all have an effect on students' interest in the flipped classroom [12]. It was reported that students who favored traditional lectures over the flipped classroom thought the flipped classroom encouraged rushed learning, and made them feel behind and inadequate [13]. Students also preferred to have subjects that require more memorization flipped, but subjects that require more explanation and discipline taught in a traditional face-to-face lecture [13]. It would be necessary to take these factors into consideration to enhance the positive outcomes of the flipped classroom.

Our previous study showed that the flipped classroom significantly improved students' performance and narrowed the learning gap between high-performing and low-performing students [14]. These results led us to question if the flipped classroom benefited one group of students more than another. Therefore, in this study, we explored students' preference of the flipped classroom as a factor impacting on their performance in assessment quizzes. Our hypothesis was that students who preferred the flipped classroom would spend more time engaging in the learning activities and perform better in quizzes than students who preferred the traditional lecture methods. We assessed students' performance after they self-studied the online materials in pre-class activity and after the entire module, the time that students spent on the pre-class activity and the assignment, and their self-evaluated understanding of the content. We also evaluated students' preferences over the flipped classroom in association with their overall performance in physiology, as well as features of the flipped classroom that students liked the most and least.

## 2. Materials and Methods

### 2.1. Ethical Statement

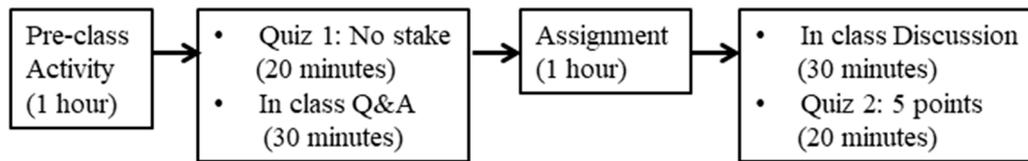
The University of the Pacific's Institutional Review Board (IRB) approved this study, proposal number #17-83.

### 2.2. Participants

Doctor of Dental Surgery (DDS) students (141 students) in their first year of the three-year DDS program at the Arthur A. Dugoni School of Dentistry, University of the Pacific, participated in this study.

### 2.3. Study Design

The dental school uses a quarterly education system, and the autonomic nervous system (ANS) is taught in the physiology course that runs across three quarters. This module was previously a three-hour lecture taught in class at the end of the first quarter. The redesigned flipped classroom module included a pre-class online learning activity, an assignment, in-class discussion, and two quizzes. Figure 1 showed the schematic diagram of the study. We designed the flipped classroom module to take roughly the same amount of time as the in-class lectures to avoid overloading the students.



**Figure 1.** Schematic diagram of the design of the flipped classroom module. The flipped classroom module replaced the original 3-h lecture on the autonomic nervous system in physiology.

**Pre-class activity (out-of-class):** Students were required to self-study foundational concepts delivered by the instructor online in their own time. The online cloud-based learning tool is VoiceThread. The online lecture included PowerPoint slides and narration from the instructor on each slide. The estimated time needed to study the online material was one hour. The pre-class activity was designed to reduce the classroom instructional time on facts-based content, and allow more time for students to do assignments and for discussion.

**Quiz 1 and Q&A (in-class):** Following online self-directed learning, students attended a voluntary one-hour face-to-face meeting in the class. At the beginning of the class, a self-assessment quiz (Quiz 1) was administered to see how well students had understood the online materials. It had ten multiple choice questions. Six questions tested students' understanding of foundational content. The other four questions were case-based and required application of knowledge. Students were given twenty minutes to complete Quiz 1. Taking Quiz 1 was voluntary and no points were assigned to the questions, which were purposefully designed to see if students would take Quiz 1 despite there being no credit. Quiz 1 questions were not released to the students after the quiz was over. The instructor was available for a discussion of the content in the pre-class activity with students after the quiz for the remaining thirty minutes.

**Assignment (out-of-class):** After the face-to-face meeting, students were given an assignment composed of three content-based questions and two cases related to the application of the ANS in clinical practice to finish at their own pace. Each case was followed with a couple of open-ended questions for discussion. Students worked on the assignment out of the class and they did not have to turn it in. There was no recommendation from instructors on whether the assignment should be done individually or as a group. Students could choose whichever way that they preferred. The estimated time for completing the assignment was about one hour.

**Discussion and Quiz 2 (in-class):** As a last step in the flipped module, students attended a mandatory one-hour face-to-face meeting. The first thirty minutes of the class were spent discussing the assigned questions and cases, followed by a self-assessment quiz (Quiz 2). Quiz 2 consisted of identical questions to Quiz 1. Students were not informed that Quiz 2 and Quiz 1 had identical questions before the quizzes. Students were given twenty minutes to complete Quiz 2. Taking Quiz 2 was voluntary and students received 0.5 bonus point per correct answer.

**Survey:** In addition to recording students' quiz scores, we administered a survey to the class two weeks after the module finished. The survey was developed by the instructor of the module and the course director with input from the Senior Faculty Developer and Instructional Designers of the school. Both the instructor and the course director had years of experience teaching the course at the time of the study. The Senior Faculty Developer has a Ph.D. in Curriculum and Instruction and had been working with dental faculties on course design for five years at the time of the study. The survey asked students to report their experiences in the flipped classroom, self-perceived understanding of the content, and their learning preferences. There were six multiple choice questions and three open-ended questions in the survey. Taking the survey was voluntary and students received one bonus point for completing the survey. Survey questions are in Supplementary Table S1.

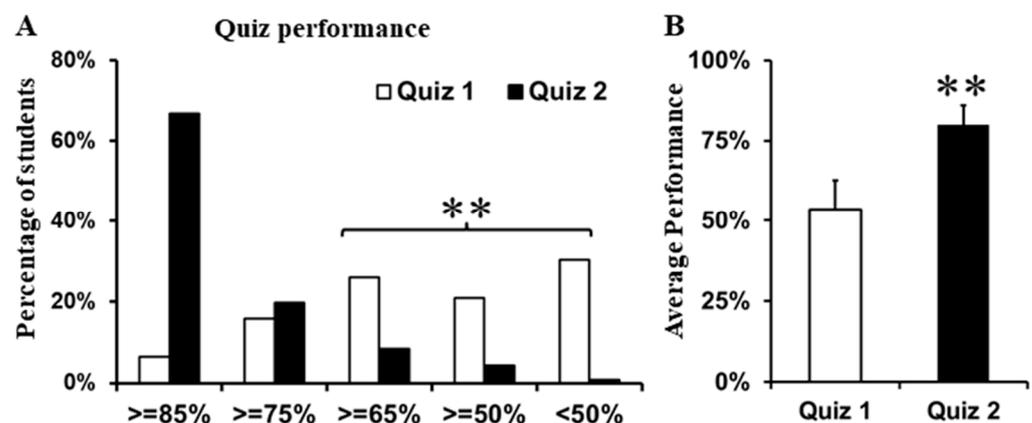
## 2.4. Data Analysis

Students' average scores on Quiz 1 and Quiz 2 were compared using Student's t-tests (2-tailed). The number of hours students spent on the pre-class online activity and the assignment, their self-evaluated understanding after pre-class online activity and the assignment, and the preferred number of flipped classroom modules in the course in relation to their Quiz 2 performance, and their final exam performance, were compared using the Chi-square test. The lower 27% and upper 27% of the class were identified based on students' performance in the cumulative final exam in the second quarter. The physiology course had a total of 375 points. The cut-off (27%) was an industry standard by default in the computer-based testing system implemented in the school. The lower 27% were considered low-performing students, and the upper 27% were considered high-performing students.  $p < 0.05$  is considered to be significant for all statistical tests.

## 3. Results

### 3.1. Students' Average Quiz Performance Improved after Assignment and Discussion

The majority of the class (138 students, 98%) took Quiz 1. All students (141 students, 100%) took Quiz 2. The highest score was 90% and 100% for Quiz 1 and Quiz 2 respectively. Significantly fewer students scored below 75% in Quiz 2 (19 students, 13%) than those in Quiz 1 (107 students, 78%,  $p < 0.01$ ) (Figure 2A). The average quiz score on Quiz 2 ( $80\% \pm 19\%$ ) was significantly higher than that of Quiz 1 ( $54\% \pm 29\%$ ,  $p < 0.01$ ) (Figure 2B).

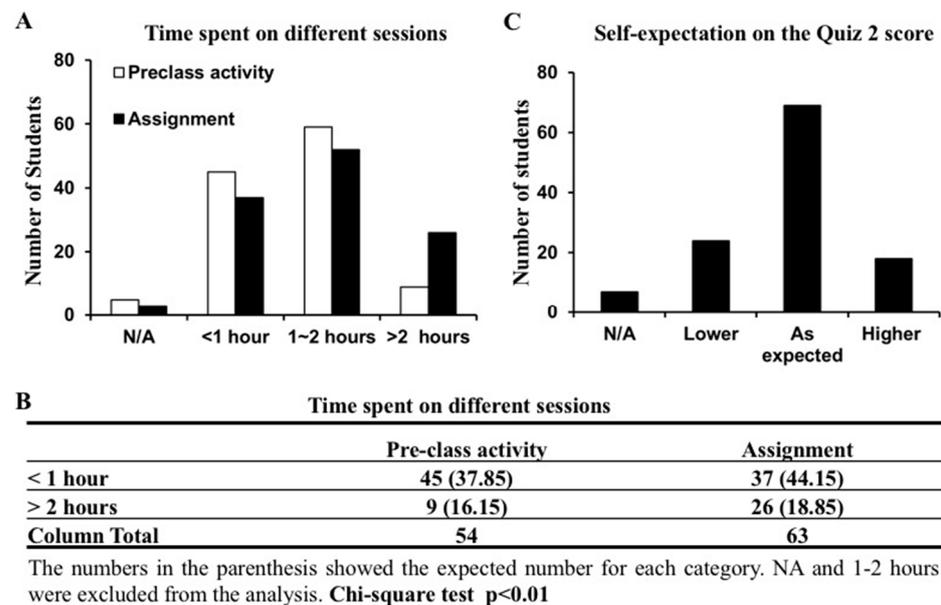


**Figure 2.** Students' average quiz performance improved after assignment and discussion. (A) Performance of students in Quiz 1 and Quiz 2. There were significantly more students scoring below 75% in Quiz 1 than in Quiz 2. (B) Average performance of students was significantly higher in Quiz 2 than in Quiz 1. \*\*  $p < 0.01$ .

### 3.2. Students' Performance Met Their Own Expectation Based on Study Time

In the survey, students were asked how much time they spent on the pre-class activity and the assignment. There were 113 and 115 students who responded to each question, respectively. Five students did not do the pre-class activity and three students did not do the assignment. Most students spent 1–2 h on either pre-class activity (59 students) or the assignment (52 students) (Figure 3A). Significantly more students spent more than two hours on the assignment (26 students,  $p < 0.01$ ), than on the pre-class activity (9 students) (Figure 3B).

Students were asked if their score on Quiz 2 met their expectation based on the time they spent on the module. Among the 118 students who responded to the question, 69 of them felt their score on Quiz 2 met their expectation. There were 24 students who felt that their scores on Quiz 2 were lower than expected, 18 students felt their scores on Quiz 2 were higher than expected, and 7 students did not have any expectation (Figure 3C).



**Figure 3.** Students' performance met their own expectation based on study time. (A) The number of students spending less than 1 h, 1–2 h, or more than 2 h on the pre-class activity and the assignment respectively. NA: Did not do the pre-class activity or the assignment. (B) Contingency table showing the observed number of students who spent less than 1 h or more than 2 h on the pre-class activity or the assignment. Chi-square test showed significant difference ( $p < 0.01$ ). (C) The number of students who felt the Quiz 2 score was lower or higher than expected or as expected based on the study time. NA: no expectation.

### 3.3. Students' Self-Rated Understanding Improved after the Assignment

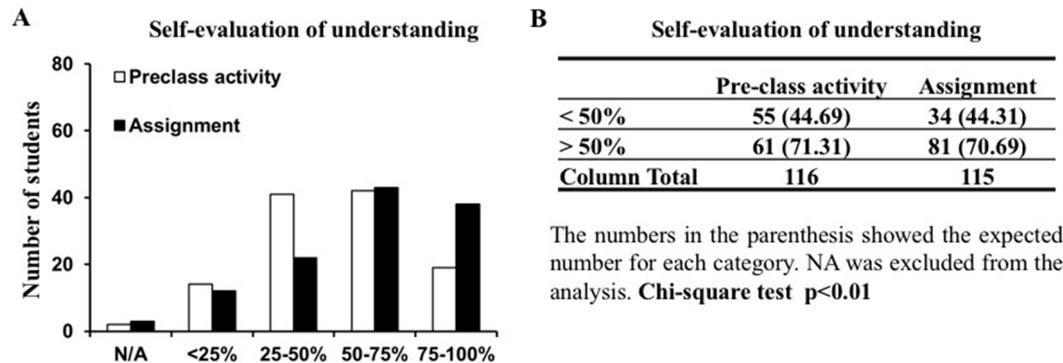
Students were also asked to rate their understanding of the physiology of the autonomic nervous system after the pre-class online activity and after finishing the assignment. There were 118 responses to both questions. Among the responders, 2 students did not do the pre-class activity and 3 students did not do the assignment. After the pre-class online activity, 14 students understood less than 25% of the content, 41 understood 25–50%, 42 understood 50–75% and 19 understood 75–100%. After the assignment, 12 students understood less than 25%, 22 understood 25–50%, 43 understood 50–75% and 38 understood 75–100% (Figure 4A). Significantly more students felt they understood more than 50% of all the content post the assignment (81 students) than post the pre-class activity (61 students,  $p < 0.01$ ) (Figure 4B).

### 3.4. High Performing Students Preferred to Have More Flipped Classroom Modules

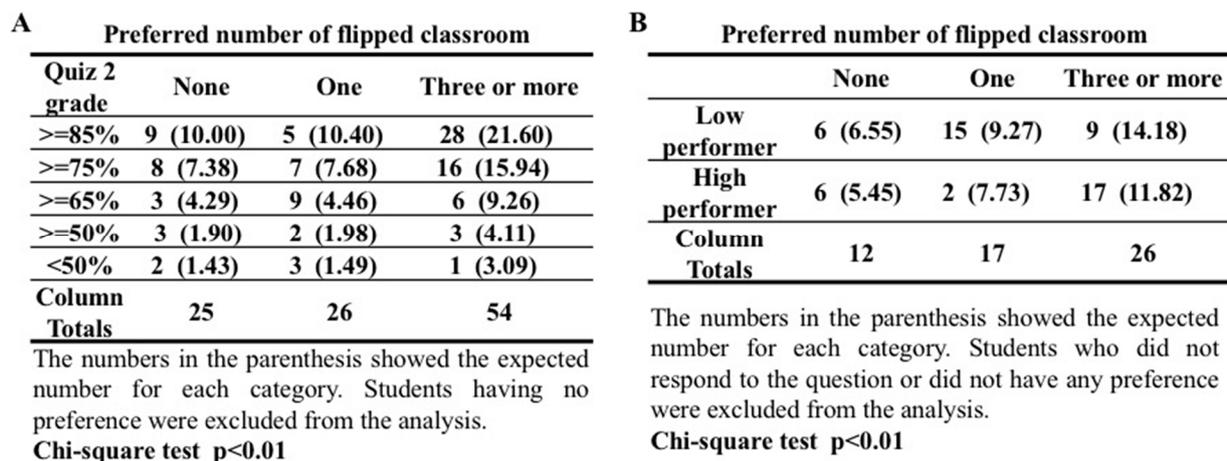
We then looked at students' performance in relation to how many flipped classroom modules they would like to have in physiology. Among 118 responders, 13 students had no preference, 25 students preferred to have none, 26 preferred to have only one, and 54 preferred to have three or more flipped classroom models. Moreover, significantly more students who preferred to have three or more flipped classroom modules scored 75% and above in Quiz 2 than students who preferred to have none or only one flipped classroom module ( $p < 0.01$ ) (Figure 5A).

Since students who preferred to have more flipped classroom modules scored higher on Quiz 2, we were curious to determine if there was a relationship between preference for the flipped classroom and overall performance as a student in the physiology course. We analyzed the preference for the flipped classroom among the high and low-performing students in physiology, based on their performance in the cumulative final. Among the 38 low-performing students (lower 27% of the class), 30 students responded to the survey. Six students preferred to have no flipped classroom modules, 15 preferred to have only one, and 9 preferred to have three or more flipped classrooms. In contrast, there were

significantly more high-performing students (upper 27% of the class) preferring to have more flipped classrooms ( $p < 0.01$ ). Among the 38 high-performing students, 25 students took the survey earlier. Six students preferred to have none, 2 preferred to have only one, and 17 preferred to have three or more flipped classrooms (Figure 5B).



**Figure 4.** Students' self-rated understanding improved after the assignment. (A) Students' self-rated understanding of the content after the pre-class activity or after the assignment. (B) Contingency table showing the observed number of students who understand less than 50% of content or more than 50% of content after the pre-class activity or the assignment. Chi-square test showed significant difference ( $p < 0.01$ ). NA: Did not do the pre-class activity or the assignment.



**Figure 5.** High performing students preferred to have more flipped classroom modules. (A) Contingency table showing the observed number of students who preferred to have none, one, and three or more flipped classroom modules in physiology stratified with their performance in Quiz 2. Chi-square test showed significant difference ( $p < 0.01$ ). (B) Contingency table showing the observed number of low performers and high performers in the cumulative final who preferred to have none, one, and three or more flipped classroom modules in physiology. The lower 27% and upper 27% of the class were identified based on students' performance in the cumulative final exam in the second quarter. The lower 27% were considered low-performing students, and the upper 27% were considered high-performing students. Chi-square test showed significant difference ( $p < 0.01$ ).

### 3.5. Students' Perceived Value and Challenges of the Flipped Classroom

In the free response section of the survey, both the low-performing and high-performing students reported that they liked the flexibility of being able to study the online materials at their own pace, the group learning on the clinical cases in the assignment, and in-class discussion of the cases. With regard to challenges of the flipped classroom, students felt that there was a lack of interpersonal communication in the pre-class online activity and that the technology used to deliver online content was not efficient. Students also felt that extra work was required during the flipped classroom module (Table 1).

**Table 1.** Features of the flipped classroom that students like the most and least.

Like the most		Like the least		
Feature	Examples	Feature	Examples	
Low performer	Flexibility	I can repeat the slides immediately and go at my own pace.	Lack of interpersonal communication	I feel like when you are on a computer and trying to learn, you get a little more distract than if you were in class. I rather have a lecture and listen to a person lecturing.
	Cases	Having the assignment related to real life clinical experiences was probably the best portion.	Too much work	I did not enjoy the flipped-classroom experience – it was done at a time of the quarter that was already overwhelming
	Group learning	It was a nice effort trying to flip it, I liked how it became a group learning thing.	Online learning Technology	The part I liked the least about the flipped-classroom experience was that the Voice Thread was difficult to get working.
High performer	Flexibility	I liked how we could learn at our own pace and go back to certain modules if we didn't understand something.	Lack of interpersonal communication	The ability to ask questions with the flipped classroom is somewhat detached, as the student would have to have the questions as they go through on their own and then email the teacher or wait until the review lecture.
	Cases	I really enjoyed then having an assignment to apply our knowledge.	Too much work	The quiz happened during a week when we had 5 exams.
	Group learning	I really like class room discussions where everyone participates. It is fun to me to learn about a concept before class and then test/expand upon my knowledge during the following class period.	Online learning Technology	I did not like how the voicethreads separated the slides into different segments. It was frustrating to keep having to click next every 30 seconds.

#### 4. Discussion

##### 4.1. Pre-Class Lecture Online vs. Assignment and Discussion in Class

Similarly to much other previous research [15,16], and consistent with our previous report [14], the results showed students' performance improved after having finished the entire flipped classroom module. Students performed significantly better on Quiz 2 than on Quiz 1. Students studied the content online on their own before taking Quiz 1. The highest score in Quiz 1 was 90%, indicating that it is possible for some students to learn course content through self-study alone. However, students' average performance on Quiz 1 was much lower than on Quiz 2.

One possible reason is that many students might have not completed the pre-class online self-paced learning activity before taking the quiz. It was largely voluntary for students to finish the pre-class activity before taking Quiz 1. Based on the survey, only 5 out of the 113 responders did not study the pre-class online materials before taking Quiz 1. However, there were 28 students who did not answer this question in the survey, making it difficult to evaluate the correlation between their survey response and performance on Quiz 1. Further studies are warranted to determine if low performers are less motivated to complete voluntary self-paced learning activities and class surveys. Educators need to keep looking for innovative pedagogic methods to motivate low performers to be more involved in learning. It is also likely that students had different background knowledge on the topic from the start. Some students might not have spent enough time on the materials. It is possible for students to have placed greater effort on performing well on Quiz 2 because the

score counted towards final grades. However, we think the higher average scores of Quiz 2 mainly reflects increased time in studying the topic through subsequent assignment and discussion. The majority of students felt their score on Quiz 2 was as expected based on the time they spent on the topic. The self-evaluation on the understanding of the content also showed that the assignment and in-class discussion helped to increase student learning of content.

The out-of-class and in-class activities have both been shown to be key components of the flipped classroom to engage students, guide students through the self-learning, and reinforce and evaluate their understanding [2,17]. In our design, the pre-class online lecture was approximately 50 min. We anticipated that students would spend about 1 h to self-study the content. Likewise, we predicted that 1 h would be sufficient to finish the assignment, which contained three content-based questions and two cases related to the application of content in the clinical practice. The survey results showed that most students spent between one and two hours on either the pre-class activity or the assignment, as expected. Interestingly, significantly more students devoted more than 2 h to complete the assignment compared to doing the pre-class activity.

This is likely because the cases in the assignment contained clinically relevant questions which required engaging and applying ANS content to answer case-based questions. Unlike the content-based questions, there were no straightforward answers to the case-based questions. Students were expected to answer case-based questions by applying the content presented in the online lecture in the pre-class activity. Additional research may also be required to answer case-based questions. Our previous findings showed that the flipped classroom module promoted peer collaboration and group learning [14]. When students studied as a group, it took more time to exchange ideas and discuss content related to the cases. In this study, instructors did not recommend completing the assignment in group or individually. It was completely up to students' preference. It would be interesting to further investigate if students who preferred to study in groups perform better than those who preferred to study individually in the flipped classroom in the future. Compared to the pre-class activity, the assignment appeared to better engage students in the learning process, which was reflected in the increased time spent doing the assignment.

Significantly more students reported that their understanding of the content improved after completing the assignment. Studying the cases in the assignment gave students the opportunity to discuss and observe the potential application of these principles to dental practice. These cases aided students' understanding of the content. The case-based questions guided the students to explore the answers for themselves. Students would be more motivated in understanding the underlying physiological mechanism. The improved average performance on Quiz 2 reflected students' effort to truly understand the concepts and utilize the information to solve clinically relevant problems.

#### 4.2. Learning Styles

Based on students' responses to the survey, the majority of the students would like to have at least one flipped classroom module in our physiology course. Interestingly, significantly more students who preferred to have three or more flipped classrooms in the course scored higher on Quiz 2 than students who preferred to have none or only one flipped classroom in the course. High-performing students in the course preferred to have three or more flipped classrooms, while the low-performing students preferred fewer flipped classrooms. According to the survey, both high-performing and low-performing students enjoyed the flexibility, case-based discussion, and group learning. However, as previously reported, high-performing students might have taken more initiatives in self-study, utilized all the resources provided, and likely explored other references [18]. This might be one of the reasons why high performers favor this model of learning more than low-performing students, who may rely more on the instructors to deliver the content.

Students' personal preference on learning styles may also have a big impact on their performance [19]. Both medical students [20] and dental students [21,22] were reported

to show multimodal learning preferences. Murphy et al. reported that dental students preferred visual learning over kinesthetic learning compared to more than 30,000 VARK (visual, aural, read/write, and kinesthetic) participants [23]. Evidence showed when the teaching methods match with the students' learning styles, students' performance could significantly improve [24,25]. We tried to accommodate students' various learning styles by incorporating images and texts in PowerPoint slides as well as adding audial narration to slides on the online learning platform (VoiceThread). However, some students might not like online learning or the online learning platform, which would diminish the likelihood of devoting time to learning the materials. This is consistent with previous findings by Kim and Frick that motivation was the best predictor of positive outcomes in self-directed online learning [26]. We did not perform a learning style survey in this study. Future work in this area is warranted to better understand the impact of learning styles on students' performance in the flipped classroom.

#### *4.3. Challenges and Limitations of the Study*

Similarly to a previous study [27], lack of interpersonal communication in the self-learning pre-class activity session was noted by the students. Although the online platform VoiceThread allows video, voice, and text comments for online question and answer, few students used the feature. Students were more active in the in-class discussion in this study. Students also noted that they were overwhelmed with work from other courses during the week when Quiz 2 took place. It would be extra effort to explore the new platform, study the materials online, and finish the assignment, if they had not previously use the designated times to do so before. Consideration of students' time and course work is an important aspect of constructing a flipped classroom module.

Another limitation of the study was that the questions were identical in Quiz 1 and Quiz 2. It was possible that students memorized the questions. However, students were not aware of this arrangement ahead of time. There was little incentive to memorize the questions during the non-stake Quiz 1. The questions, answers, and students' performance in Quiz 1 were not released to the students, also making it harder to remember the questions.

Furthermore, this study employed a post-survey design. The survey was distributed to the students two weeks after the flipped classroom. The post-module survey did not reflect students' preference of the flipped classroom before the module. However, students' preference of one learning method is subject to change due to their learning experience during the module and performance in the quizzes. Students' memory of the flipped classroom module could also become blurry two weeks after the flipped classroom was over. Future studies could investigate if students' learning preferences change through flipped classroom learning by administering pre- and post-module surveys.

Additionally, this study examined students' preference for learning and its correlation with assessment performance in one flipped classroom module. There are other variables that could have impacted students' learning performance that need to be thoroughly evaluated in future research. Such studies will provide valuable information to help the faculty better support students' academic success.

Finally, the study was conducted in a single dental school. The students in this study were generally high performers based on their undergraduate performance. Having students of greater diversity may also have an impact on the findings. This study was also conducted for a biomedical science course. Future studies to compare students with more variances in background and in different disciplines will give better understanding of the impact of preference for learning on learning outcomes with the flipped classroom.

## **5. Conclusions**

Despite the increasing interest in the flipped classroom approach in dental education, carefully designed flipped modules are necessary to motivate as many students as possible to learn. Factors such as the components of the flipped classroom module, the baseline

knowledge of students, learning preference of the students, the context of the educational approach, and assessment of the learning outcomes shall be considered.

Our findings suggested that guided self-study such as the assignment was strongly related to dental students' better performance in physiology. Students spent more time on the assignment, which included not only content-based questions but also case-based questions relevant to clinical practice. High-performing students tended to prefer the flipped classroom more than low-performing students. When integrating the flipped classroom method into biomedical courses for professional students, instructors need to design the module carefully and include components to engage as many students as possible and to improve the efficacy of this pedagogical model.

**Supplementary Materials:** The following are available online at <https://www.mdpi.com/article/10.3390/educsci11040150/s1>, Table S1: ANS Flipped Classroom Module Survey.

**Author Contributions:** Conceptualization, N.X. and D.T.; methodology, N.X., D.T. and M.Z.; validation, N.X., D.T. and M.Z.; formal analysis, N.X.; investigation, N.X. and D.T.; resources, N.X., D.T., and M.Z.; data curation, N.X.; writing—original draft preparation, N.X.; writing—review and editing, N.X., D.T., and M.Z.; supervision, N.X. All authors have read and agreed to the published version of the manuscript.

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**Institutional Review Board Statement:** The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the University of the Pacific's Institutional Review Board (protocol number #17-83, 04/10/2017).

**Informed Consent Statement:** Participant consent was waived due to the research is done on existing data from the course and the researchers are unable to individually identify a subject based upon information provided with the data.

**Data Availability Statement:** Not Applicable.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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