Teaching Exercise Physiology with Flipped Classroom Method in The Era of COVID-19: Experience of a Remote Course

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Abstract

Purpose: The purpose of this article is to describe the use of flipped classroom method in a forced remote Exercise Physiology course during the COVID-19 pandemic and assess the students’ motivation and learning throughout the course. METHODS: Undergraduate students received recorded asynchronous activities each week that should be done before a weekly synchronous meeting. During synchronous and asynchronous activities, strategies to emphasize students’ active participation were applied. Weekly, learning evaluation activities were applied, and the motivation was assessed. At the end of the course, students’ motivation and learning about each activity were evaluated. RESULTS: Of the 14 course topics, 2 were rated as “extremely motivated”, 11 as “very motivated” and 1 as “motivated”. Furthermore, motivation was positively correlated with learning, and students attributed high scores to all activities, except for group activity. CONCLUSION: The flipped classroom methodology employs different active teaching strategies, motivates, and contributes to students learning, an option to remotely teach exercise physiology.

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Teaching Exercise Physiology with Flipped Classroom Method in The Era of COVID-19: Experience of a Remote Course

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ABSTRACT

Purpose: The purpose of this article is to describe the use of flipped classroom method in a forced remote Exercise Physiology course during the COVID-19 pandemic and assess the students' motivation and learning throughout the course.

METHODS: Undergraduate students received recorded asynchronous activities each week that should be done before a weekly synchronous meeting. During synchronous and asynchronous activities, strategies to emphasize students' active participation were applied. Weekly, learning evaluation activities were applied, and the motivation was assessed. At the end of the course, students' motivation and learning about each activity were evaluated. RESULTS: Of the 14 course topics, 2 were rated as "extremely motivated", 11 as "very motivated" and 1 as "motivated". Furthermore, motivation was positively correlated with learning, and students attributed high scores to all activities, except for group activity. CONCLUSION: The flipped classroom methodology employs different active teaching strategies, motivates, and contributes to students learning, an option to remotely teach exercise physiology.

KEYWORDS: teaching method, remote learning, online teaching, recorded remote classes; active activities.
INTRODUCTION

The COVID-19 pandemic has precipitously and significantly altered the global education process. The order to shelter in place during the pandemic imposed the implementation of remote learning, and both students and teachers had to face this new reality. A recent review raised substantial insights into the challenges encountered during the e-learning process in the context of the pandemic. Noteworthy findings encompass difficulties in accessing online platforms, technical issues experienced during virtual classes, and recurring problems with internet connectivity, most notably in underdeveloped regions. Furthermore, a lack of privacy and inadequate physical learning environments were also identified as prevalent impediments.\(^1\) These findings from the review underscore the presence of external barriers to the e-learning process. In addition to these external challenges, internal obstacles such as diminished student motivation and unmet expectations assume paramount significance.\(^2\) Motivation emerges as a pivotal factor within the process of acquiring new knowledge, as emphasized in prior research.\(^3-6\)

To face the external challenge concerning the limited access to online learning, asynchronous classes (recorded) were assumed as a viable option. However, when used as a single learning strategy, asynchronous activities do not allow interaction between teacher and students, decreasing the possibility of discussing topics, asking questions, and solving doubts. Thus, the association of asynchronous activities with synchronous classes became a more attractive option. Additionally, the use of student-centered teaching approaches, such as the flipped classroom, may bring better learning results.\(^6,7\)

The flipped classroom is defined as an instructional approach that grants students access to course materials in advance (asynchronous) before engaging in direct interaction with the instructor (synchronous). This methodology fosters the cultivation of a diverse set of skills during synchronous sessions, expanding beyond the mere acquisition of subject matter knowledge. These encompass critical and creative thinking, effective communication and writing, decision-making, self-directed learning, problem-solving, and collaborative teamwork. Consequently, the integration of these methodologies collectively enriches the overall learning experience.\(^8,9\)

This method had been employed prior to the pandemic and was identified as a more effective approach than traditional teaching methods for students enrolled in health professional programs. This assessment emerged from a meta-analysis encompassing 28 studies.\(^10\) Subsequently, the adoption of this methodology has experienced a surge in prevalence, particularly following the onset of the COVID-19 pandemic, which necessitated the widespread implementation of remote learning. Furthermore, advancements in technology have facilitated the integration of novel remote tools.\(^8\)

In the remote application of this student-centered approach, students have the opportunity to acquaint themselves with the course material through asynchronous activities prior to engaging in remote synchronous sessions with the teacher. Both synchronous and asynchronous learning modalities can incorporate diverse strategies, including dynamic and interactive activities, which have been demonstrated to effectively sustain student motivation and engagement.\(^11\) While the pandemic’s impact is gradually diminishing, educational processes may continue to harness the benefits of remote learning experiences. Consequently, a hybrid format, blending in-person and remote instruction, may prove advantageous in the post-COVID-19 era. To facilitate this transition, insights gained from the remote teaching expertise developed during the pandemic assume paramount importance.

Thus, the purpose of this study was to present the (forced - in which the students could not choose between in-person or online classes) remote experience obtained in a course of Exercise Physiology conducted during the COVID-19 pandemic. For this purpose, the present study was designed to: a) describe the methodology adopted using the flipped classroom with synchronous and asynchronous activities and employing different learning strategies; b) assess the weekly students’ motivation throughout the course; and c) evaluate the students’ opinion regarding the contribution of each activity for their motivation and learning.

METHODS

Participants

The study population was the students who signed up for the Exercise Physiology I course in 2021. This course is offered for obtaining the degree of bachelor's in physical education or sport (similar to Kinesiology/Exercise Science), and it is usually offered for students who are in the third semester of the Bachelor course. In 2021, 120 registered for this course and 66 (19 women and 47 men) agreed to take part in the present study by signing a written informed consent.
**Procedures**

The Exercise Physiology course comprised 14 content topics. The methodology adopted was the flipped classroom (Figure 1), in which the students were asked to perform recorded asynchronous activities previously to a weekly synchronous meeting. Additionally, each week, after the synchronous meeting, learning evaluation activities were applied, and the motivation score was assessed. At the end of the course, the students answered a questionnaire with their opinions regarding the contribution of each activity to their motivation and learning.

*Figure 1. Schematic Representation of the Flipped Classroom Method Employed*

The content topics and the specific activities used for asynchronous and synchronous strategies can be seen in table 1.

*Table 1. Topics and Activities Employed Throughout the Course.*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Recorded asynchronous activities</th>
<th>Synchronous meeting activities</th>
<th>Learning Evaluation activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Skeletal muscle physiology</td>
<td>Recorded lectures and recorded videos with practical demonstrations</td>
<td>Expository lessons and evaluative activity feedback</td>
<td>Post-Content evaluative questionnaires</td>
</tr>
<tr>
<td>2. Adaptations in skeletal muscle to aerobic training</td>
<td>Recorded lectures</td>
<td>Expository lessons, evaluative activity feedback, and video discussion</td>
<td>Post-Content evaluative questionnaires</td>
</tr>
<tr>
<td>3. Adaptations in skeletal muscle to anaerobic training</td>
<td>Recorded lectures</td>
<td>Expository lessons and evaluative activity feedback</td>
<td>Post-Content evaluative questionnaires</td>
</tr>
<tr>
<td>4. Adaptations in skeletal muscle to strength training</td>
<td>Recorded lectures</td>
<td>Expository lessons, evaluative activity feedback and case discussion</td>
<td>Post-Content evaluative questionnaires</td>
</tr>
<tr>
<td>5. Strategies to improve strength and hypertrophy</td>
<td>Recorded lectures with interactions</td>
<td>Expository lessons, evaluative activity feedback and video discussion</td>
<td>Pre- and Post-Content Evaluative questionnaire</td>
</tr>
<tr>
<td>Topic</td>
<td>Recorded activities</td>
<td>Synchronous activities</td>
<td>Learning Evaluation activities</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>---------------------</td>
<td>------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>6. Flexibility training physiology</td>
<td>Recorded lectures and recorded videos with practical demonstrations</td>
<td>Expository lessons, evaluative activity feedback and video discussion</td>
<td>Post-Content evaluative questionnaires</td>
</tr>
<tr>
<td>7. Basic cardiovascular physiology</td>
<td>Recorded lectures</td>
<td>Expository lessons and evaluative activity feedback</td>
<td>Pre- and Post-Content Evaluative questionnaire</td>
</tr>
<tr>
<td>8. Cardiovascular acute responses to aerobic and strength exercises</td>
<td>Recorded lectures and recorded videos with practical demonstrations</td>
<td>Expository lessons, evaluative activity feedback, video discussion</td>
<td>Group activity</td>
</tr>
<tr>
<td>9. Cardiovascular chronic responses to aerobic and strength exercise</td>
<td>Recorded lectures</td>
<td>Expository lessons and evaluative activity feedback</td>
<td>Post-Content evaluative questionnaires</td>
</tr>
<tr>
<td>10. Cardiovascular risk screening for exercise</td>
<td>Recorded videos with practical demonstrations</td>
<td>Expository lessons, evaluative activity feedback and case discussion</td>
<td>Practical screening</td>
</tr>
<tr>
<td>11. Maximal incremental exercise test execution</td>
<td>Recorded videos with practical demonstrations</td>
<td>Expository lessons, evaluative activity feedback and case discussion</td>
<td>Analyze exams and prescribe exercise</td>
</tr>
<tr>
<td>12. Maximal incremental exercise test analysis</td>
<td>Recorded lectures</td>
<td>Expository lessons, evaluative activity feedback and case discussion</td>
<td>Analyze exams and prescribe exercise</td>
</tr>
<tr>
<td>13. Aerobic exercise prescription</td>
<td>Recorded lectures</td>
<td>Expository lessons, evaluative activity feedback and case discussion</td>
<td>Analyze exams and prescribe exercise</td>
</tr>
<tr>
<td>14. Discussion about final integrative evaluation</td>
<td>Recorded lectures</td>
<td>Expository lessons, evaluative activity feedback and case discussion</td>
<td>Integrative evaluation</td>
</tr>
</tbody>
</table>

**Recorded Asynchronous Activities**

The asynchronous recorded activities were made available weekly, and students could watch repeatedly. The following activities were employed and evaluated:

- **Recorded lectures**: the professor recorded expository lectures related to the topic of the week.
- **Recorded lectures with interactions**: the professor recorded expository lectures pertaining to weekly content. During these lectures, students were required to engage with the material by responding to quizzes in order to progress through the lecture.
- **Recorded videos with practical demonstrations**: the professor recorded practical demonstrations related to the content of the week.

**Synchronous Meetings Activities**

The synchronous meeting occurred on the university’s online platform (google meet). These sessions incorporated a diverse array of activities with the primary goal of fostering active student engagement. These activities included the use of videos, case studies, questionnaires, and surveys. The following activities were evaluated:

- **Expository lessons**: recalling the key points of the remote content, giving additional content, and solving doubts.
- **Evaluative activity feedback**: discussion of the key points of the last evaluative activity.
- **Case discussions**: real-life cases that were discussed and solved by the students (e.g., a person with specific characteristics who will enroll in an exercise program).
Learning Evaluation Activities
An objective learning evaluation was remotely applied every week using the following activities that were evaluated at the end of the course included:

- **Post-content evaluative questionnaires**: online questionnaires applied after the synchronous meeting with different types of questions: single choice, multiple choice, true or false, complete the phrase, associated words, and chart interpretations.
- **Pre- and post-content evaluative questionnaire**: the same questionnaire was applied before and after developing content to evaluate students' acquisition.
- **Group activity**: after a practical demonstration, students had to make a report in groups.
- **Practical screening**: the students had to apply a cardiovascular risk screening in different persons.
- **Analyze exams and prescribe exercise**: the students had to analyze tests and prescribe exercise.
- **Integrative evaluation**: the students had to analyze a complete case from screening to exercise prescription, applying all previous content.

Weekly Motivation Assessment
After each week's synchronous meeting, beginning in the second week, the students' motivation was assessed by a five-point Likert scale applied to the question: *How was your motivation to take this course this week?* with 0 = not at all motivated; 1 = a little motivated; 2 = moderately motivated; 3 = very motivated; and 4 = extremely motivated.

Opinion About Activities
At the end of the course, the students were asked to attribute a score (1 = very little; 2 = little, 3 = more or less; 4 = much, and 5 = very much) regarding their opinion about how much each activity contributed to their motivation and learning.

Data Analysis
Data are presented in mean and standard deviation. A one-way ANOVA was performed to compare students' opinions about how much each activity contributed to their motivation and learning, when a significant difference was observed, the Tukey post-hoc was performed. Associations between motivation and learning scores self-reported by the students and for each activity were analyzed by Pearson's correlation. Data were analyzed using Statistics for Windows. In all analyses, a significance level was set at 5% (p < 0.05).

RESULTS
The average final score of the students that agreed to participate in this present study was 8.1 ± 1.2 on a scale from 0 to 10. Attendance at the synchronous meeting was 95.7 ± 5.9%. Answers to the weekly motivation scale ranged from 68 to 33% of the students, decreasing along the course. From the 14 content topics, two were mainly rated as "extremely motivated", while the remaining were mainly rated as "very motivated", and one as "motivated" (Table 2).

<table>
<thead>
<tr>
<th>Topic</th>
<th>Extremely motivated</th>
<th>Very motivated</th>
<th>Motivated</th>
<th>Little motivated</th>
<th>Not at all motivated</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeletal muscle physiology</td>
<td>11 (24.4%)</td>
<td>25 (55.6%)</td>
<td>8 (17.8%)</td>
<td>1 (2.2%)</td>
<td>-</td>
<td>45</td>
</tr>
<tr>
<td>Adaptations in skeletal muscle to aerobic training</td>
<td>6 (24.0%)</td>
<td>11 (44.0%)</td>
<td>8 (32.0%)</td>
<td>-</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>Adaptations in skeletal muscle to anaerobic training</td>
<td>12 (34.3%)</td>
<td>18 (51.4%)</td>
<td>5 (14.3%)</td>
<td>-</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td>Adaptations in skeletal muscle to strength training</td>
<td>18 (58.1%)</td>
<td>7 (22.6%)</td>
<td>5 (16.1%)</td>
<td>1 (3.2%)</td>
<td>-</td>
<td>31</td>
</tr>
<tr>
<td>Strategies to improve strength and hypertrophy</td>
<td>9 (34.6%)</td>
<td>10 (38.5%)</td>
<td>6 (23.1%)</td>
<td>1 (3.8%)</td>
<td>-</td>
<td>26</td>
</tr>
<tr>
<td>Topic</td>
<td>Extremely motivated</td>
<td>Very motivated</td>
<td>Motivated</td>
<td>Little motivated</td>
<td>Not at all motivated</td>
<td>Respondents</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
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<td>------------------</td>
<td>----------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Flexibility training physiology</td>
<td>9 (27.3%)</td>
<td>15 (45.5%)</td>
<td>9 (27.3%)</td>
<td>-</td>
<td>-</td>
<td>33</td>
</tr>
<tr>
<td>Basic cardiovascular physiology</td>
<td>7 (20.0%)</td>
<td>15 (24.9%)</td>
<td>9 (25.7%)</td>
<td>3 (8.6%)</td>
<td>1 (2.9%)</td>
<td>35</td>
</tr>
<tr>
<td>Cardiovascular acute responses to aerobic and strength exercises</td>
<td>11 (30.6%)</td>
<td>13 (36.1%)</td>
<td>10 (27.8%)</td>
<td>2 (5.6%)</td>
<td>-</td>
<td>36</td>
</tr>
<tr>
<td>Cardiovascular chronic responses to aerobic and strength exercises</td>
<td>7 (21.9%)</td>
<td>14 (43.8%)</td>
<td>10 (31.3%)</td>
<td>1 (3.1%)</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>Cardiovascular risk screening for exercise</td>
<td>11 (29.7%)</td>
<td>16 (43.2%)</td>
<td>8 (21.6%)</td>
<td>2 (5.4%)</td>
<td>-</td>
<td>37</td>
</tr>
<tr>
<td>Maximal incremental exercise test execution</td>
<td>6 (20.0%)</td>
<td>16 (53.3%)</td>
<td>6 (20.0%)</td>
<td>2 (6.7%)</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Maximal incremental exercise test analysis</td>
<td>7 (26.9%)</td>
<td>10 (38.5%)</td>
<td>7 (26.9%)</td>
<td>1 (3.8%)</td>
<td>1 (3.8%)</td>
<td>26</td>
</tr>
<tr>
<td>Aerobic exercise prescription</td>
<td>7 (26.9%)</td>
<td>13 (50.0%)</td>
<td>4 (15.4%)</td>
<td>2 (7.7%)</td>
<td>-</td>
<td>26</td>
</tr>
<tr>
<td>Discussion about final integrative evaluation</td>
<td>13 (59.1%)</td>
<td>5 (22.7%)</td>
<td>3 (13.6%)</td>
<td>1 (4.5%)</td>
<td>-</td>
<td>22</td>
</tr>
</tbody>
</table>

Thirty-eight students (58% of the total sample, 10 women and 28 men) answered about the contribution of each activity to their motivation and learning (Figure 2). For both aspects, most of the activities (12 from 13) were averaged between 4 and 5, except for “Group activity” which was scored 3.3 ± 1.2 for motivation and 3.3 ± 1.3 for learning. A one-way ANOVA revealed a significant difference in learning and motivation between activities analyzed (F = 9.94; p < 0.001; F = 16.26; p < 0.001; respectively); being “Group activity” scores lower than all other activities for both learning and motivation (p < 0.05 for all comparisons).
Figure 2: Students' opinion about how much each activity has motivated them (grey) and contributed to their learning (blue). Data are mean ± standard deviation. * = different from other activities (p < 0.05).
For all activities, a significant and positive correlation was detected between motivation and learning scores (Table 3).

**Table 3.** Correlations between the motivation and the learning scores for each recorded asynchronous, synchronous meeting, and learning evaluation activities

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Pearson's r</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recorded asynchronous activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recorded lectures</td>
<td>0.32</td>
<td>0.0484</td>
</tr>
<tr>
<td>Recorded lectures with interactions</td>
<td>0.67</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Recorded videos with practical demonstrations</td>
<td>0.72</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Synchronous meeting activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expository lessons</td>
<td>0.85</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Evaluative activity feedback</td>
<td>0.60</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Case discussions</td>
<td>0.61</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Videos discussion</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Learning evaluation activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Content Evaluative questionnaires:</td>
<td>0.81</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pre- and Post-Content Evaluative questionnaire</td>
<td>0.78</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Group activity</td>
<td>0.78</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Practical screening</td>
<td>0.63</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Analyze exams and prescribe exercise</td>
<td>0.65</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Integrative evaluation</td>
<td>0.85</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

**DISCUSSION**

In the present study, we observed that the implementation of the flipped classroom method, which involved pre-recorded asynchronous activities followed by weekly synchronous sessions incorporating active learning strategies and subsequent learning assessment activities, effectively promoted and sustained students' motivation throughout the entire course. We also observed that according to the students' opinions activities were highly motivating and contributed to their learning. Finally, motivation and learning appear to be correlated.

Based on the current findings, it can be inferred that the flipped classroom method emerges as an effective strategy for enhancing student motivation. This assertion is substantiated by the notably high weekly motivational scores reported in the present study. It is noteworthy that achieving such high motivational scores in a completely remote course runs counter to expectations, as motivation has been commonly identified as a challenge in the context of remote learning. However, as the course was conducted during the COVID-19 pandemic when social interaction was decreased, the use of an active learning process may have contributed to motivation.

Indeed, the current findings align with previous research, which demonstrated the effectiveness of employing the flipped classroom method in a completely remote Basic Physiology course during the pandemic. In this study, students reported improvements from the beginning to the end of the semester: improvement in their confidence for completing the course (p < 0.05), well adjustment to flipped classroom method (p < 0.001), and gain of knowledge (p < 0.001). The gain of these abilities may have contributed to motivation. Interestingly, almost all proposed activities contributed between “much” and “very much” to the students' motivation and learning.

Nonetheless, it is worth noting that "Group activity" received lower ratings compared to other activities. This observation might appear paradoxical, given the prevailing notion that interactive activities tend to be motivating. However, it's important to consider that in the present study, students were not given the autonomy to select their group partners; instead, group assignments were determined through random allocation. The fact that students could not choose their partners may have contributed to the lower motivation scores associated with the group activity since the students were compelled to collaborate with partners whom they were unfamiliar or had a limited affinity.

While we did not find scientific evidence in the existing literature comparing groups formed by students' choice to those formed by random assignment, we did receive feedback from students who expressed dissatisfaction with their inability to select their own partners. Another potential factor contributing to the lower motivation score may be the lack of clear task allocation among students or guidance from instructors, as students worked independently without direct oversight from professors. It is important to note that cooperative tasks, such as group activities, tend to be more effective when specific factors are in place. In fact, some students reported uneven participation among group members in these assignments.
Another possible contributing factor to this lower motivation score could be the use of video conferences for group discussions, which may be less time-efficient and more fatiguing compared to face-to-face group interactions.\textsuperscript{14} Therefore, the planning of entirely remote courses should carefully consider the nature of group activity tasks.

It is not new that motivation is important to learning and the positive correlation between motivation and learning scores observed in the present study corroborates with this issue.\textsuperscript{5-5} As recently raised in a review about the past, the present, and the future of flipped teaching, the number of studies about Flipped classroom has increased expressively after 2019 and tends to increase even more because of the rising of technological implementations imposed by COVID-19.\textsuperscript{7} These authors highlighted that we are at an inflection point in which new technologies may emerge and refine flipped classroom method.

One key concern about flipped classroom method is the generalization of the outcomes since it is possible to acquire different outcomes according to sex, nationality, the year of the student, characteristics of instruction, and more importantly the course analyzed.\textsuperscript{8,10,15-17} About differences in courses, a meta-analysis involving 55 studies (115 comparisons) that cognitive student learning was higher in flipped classroom method (n = 3727 students) than in traditional ones (n = 4185) in various courses.\textsuperscript{17} Moderator analysis revealed differences by subject area but not for student level, study duration, or publication type. Social sciences, science, mathematics, arts, and humanities presented statistically higher effect sizes than engineering, not being a suitable candidate for the flipped classroom method when compared to other disciplines. Thus, the impact of flipped classroom seems to be course dependent.\textsuperscript{17}

In this study, we demonstrate the implementation of the flipped classroom method within the context of an Exercise Physiology course, predominantly attended by students enrolled in Kinesiology / Exercise Science / Physical Education programs. Recognizing the necessity to cultivate a broad spectrum of professional competencies throughout an undergraduate curriculum, as for example problem-solving proficiency, and the capacity for professional decision-making, it becomes evident that active learning constitutes a pertinent approach to enhance the teaching-learning process; and the flipped classroom method is a prime example of such type of active learning.\textsuperscript{18}

The students usually report Exercise Physiology as one of the most difficult topics in Exercise Science/Kinesiology/Physical Education undergraduate college.\textsuperscript{19} In addition, Exercise physiology is often a required course in several academic majors within kinesiology/exercise science/physical education, but also in preparation for careers in medicine, physical therapy, and occupational therapy. Beyond being a component of the kinesiology/exercise science curriculum, exercise physiology is also growing as an academic major. Employment opportunities for exercise physiologists are on the rise.\textsuperscript{20} Thus, it would be beneficial to understand in this cornerstone course the most effective teaching methods. However, to the best of our knowledge, we did not find a 100% remote Exercise Physiology course utilizing flipped classroom.

Strategies using practical activities have been encouraged and utilized to optimize the teaching-learning process in this type of course.\textsuperscript{21,22} For example, a recent study demonstrated that students’ enrolled in the Exercise Physiology course were submitted to an active activity in which they could learn more about basic concepts of the heart as a pump (pre-load, post-load, and contractility) due to an artificially constructed model of the cardiovascular system (utilizing Tygon tubing, one-way valves, balloon, hole rubber stopper, and a 60-ml syringe with and without the plunger)\textsuperscript{22,23}; were capable to recalling relevant basic concepts of cardiovascular physiology that were important to understand exercise cardiovascular physiology.

We also found studies utilizing hybrid/blended teaching (online lectures recorded followed by a subsequent presential class).\textsuperscript{21,24} These studies found that final students’ grades were 9.9% higher in the hybrid method compared to a traditional (100% presential), or that recorded videos before class enhanced students’ perceptions about learning of course material.\textsuperscript{21,24}

It is important to note that we are teaching a new era of students’ who are considered digital natives, seeming that their learning acquisition differs from other previous generations.\textsuperscript{25,26} In this context, the outcomes derived from our remote teaching experience employing the flipped classroom method, as presented in this study, corroborate the notion that the suggested pedagogical method (Flipped classroom with synchronous and asynchronous active activities) proved to be effective in both motivating students’ and providing instruction within the framework of a remote undergraduate course. However, this approach was applied during the COVID-19 pandemic when the students were forced to stay at home.

Thus, application in a remote course after a pandemic or in a hybrid course raises some questions: Will the student have the self-discipline to watch the recorded asynchronous classes when they have outside activities to be performed? What are the most effective active activities to be developed in a remote (non-forced) exercise physiology course? These questions are open for debate and need to be approached by future research.
Limitations
The present study has some limitations. First, not all the students who signed up for the course of Exercise Physiology agreed to participate in the study, being possible that those who agreed already had a greater degree of motivation. Second, due to the difficulties imposed by COVID-19, the study did not include a control group using the traditional teaching methodology for comparison.

CONCLUSIONS
The flipped classroom method applying active synchronous and asynchronous activities was effective to teach Exercise Physiology in a totally remote undergraduate course during the COVID-19 pandemic. The students kept high motivation levels throughout the course and according to their opinion, most of the proposed activities motivated and contributed to their learning with Group activity having a lower impact on these aspects. Our study described and demonstrated that flipped classroom method followed by remote synchronous activities to promote critical thinking and learning is an efficient teaching strategy in the kinesiology area.

Disclosure statement
No potential conflict of interest was reported by the authors.

References