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Academic Performance and Perceptions Regarding the Flipped Classroom Strategy in the Subject of Human Anatomy

Camila Maria Bandeira Scheunemann[a]
Paulo Tadeu Campos Lopes[a]

[a] Universidade Luterana do Brasil (ULBRA), Programa de Pós-Graduação em Ensino de Ciências e Matemática – PPGECIM, Canoas, RS, Brasil

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ABSTRACT

Background: The flipped classroom is considered an initial path to introduce blended learning; however, studies on this strategy are incipient in the discipline of Human Anatomy**. Objective**: To analyse the impact of the flipped classroom on the performance of Human Anatomy students in health courses and their perceptions regarding the learning process. **Design**: It is characterised as a mixed approach case study. **Setting and Participants**: Two groups of Human Anatomy students from courses in the health area of a university in the metropolitan region of Porto Alegre/RS. **Data collection and analysis**: Flipped classes were held, with digital hypertexts as prior material and application activities in the face-to-face stage. Data were collected by questionnaires and analysed by the scores of answers and McNemar's statistical test (quantitative) and by content analysis (qualitative). **Results**: The results showed statistical significance in the dichotomous questions in relation to performance. As for the perceptions, there was agreement on the aid of the flipped classroom for learning in the two groups. It was also observed that the perceptions regarding the understanding of the content became more satisfactory as the classes evolved. **Conclusions**: The flipped classroom was presented as a potential strategy in teaching and learning in the subject matter of human anatomy in the investigated context.

Keywords: Flipped classroom; Human anatomy; Teaching and learning; University Education, Blended learning.

Corresponding author: Camila Maria Bandeira Scheunemann. Email: camila.b91@hotmail.com

Desempenho Acadêmico e Percepções Referentes à Estratégia Sala de Aula Invertida na Disciplina de Anatomia Humana

RESUMO

Contexto: A sala de aula invertida é considerada um caminho inicial para introduzir o ensino híbrido; no entanto, os estudos sobre essa estratégia apresentam-se incipientes na disciplina de Anatomia Humana. **Objetivo**: Analisar o impacto da sala de aula invertida no desempenho de acadêmicos de anatomia humana de cursos da área da saúde e de suas percepções em relação ao processo de aprendizagem. **Design**: Caracteriza-se como um estudo de caso de abordagem mista. **Ambiente e participantes**: Duas turmas de acadêmicos de Anatomia Humana de cursos da área da saúde de uma universidade da região metropolitana de Porto Alegre/RS. **Coleta e análise de dados**: Realizaram-se aulas invertidas, com hipertextos digitais como material prévio e atividades de aplicação na etapa presencial. Os dados foram coletados por questionários e analisados pelos escores das respostas e teste estatístico de McNemar (quantitativos) e pela Análise de Conteúdo (qualitativos). **Resultados**: Os resultados evidenciaram significância estatística nas questões dicotômicas em relação ao desempenho. Quanto às percepções, houve concordância sobre o auxílio da sala de aula invertida para a aprendizagem nas duas turmas, sendo 76,9% no primeiro semestre e 100% no segundo semestre. Observou-se, ainda, que as percepções a respeito do entendimento do conteúdo tornaram-se mais satisfatórias com o passar das aulas. **Conclusões**: A sala de aula invertida apresentou-se como uma estratégia potencial no ensino e aprendizagem na disciplina de Anatomia Humana no contexto investigado.

Palavras-chave: Sala de aula invertida; Anatomia Humana; Ensino e aprendizagem; Ensino Superior; Ensino híbrido.

INTRODUCTION

Contemplating the contemporary pandemic scenario and its implications, debates and research regarding blended learning have intensified, aiming at a deeper understanding of the impacts and transformations that have taken place in educational institutions. Silveira (2020) points out that the coronavirus pandemic has affected all aspects of human life, including education, due to which blended learning has been seen as a post-pandemic trend. Along the same lines, Araya-Moya et al. (2022) believe that the pandemic revealed the need for content virtualisation and encourages active participation and student co-responsibility in acquiring knowledge.

Despite this recent debate, blended learning has been investigated for a long time as a strategy that aims to integrate face-to-face and online

teaching. Such research, carried out mainly in North American and European countries, culminated in the classification of blended learning modalities, such as those mentioned by Christensen, Horn, and Staker (2013), including sustained rotation models (such as station rotation, rotational laboratory, and the flipped classroom - FC), and disruptive models (such as flex, *à la carte* and virtual enriched).

Among these modalities, flipped classroom is considered the baseline for the introduction of blended learning, as it represents a sustained strategy that does not require profound changes in the structure of educational institutions to be implemented (Bacich, Neto & Trevisani, 2015). The FC includes the online study stages (pre-class/individual space) and face-to-face study (or group study), as defined by authors such as Bergmann and Sams (2014; 2018) and Talbert (2019).

For Santos, Mercado, and Pimentel (2021), the FC has found space at different levels of education, driven by the advancement of digital technologies and the movement towards active learning, consistent with the advances of post-industrial society. Pinto et al. (2021, p. 15) emphasise that there are no rules to be followed in this approach but that "there are four guiding pillars: flexible environment, learning culture, the intentionality of the distributed content, and educator professionalism".

Scholars such as Schmitz and Reis (2018) and Freitas and colleagues (2021) comment that the FC has drawn researchers' attention as a potential for use in higher education and graduate studies. As flipped classes demand a high degree of commitment and responsibility, students must be more mature, which explains the interest in these educational levels.

Research on the FC has approached different aspects of the methodology. Nevertheless, some particularities must be investigated, such as the stages to be taken, previous materials, classroom activities, and students' mobilisation for the desired posture in this modality (active, autonomous, and protagonist stances), among other issues. In this sense, some elements such as engagement, pre-class materials, and face-to-face/group activities have been the object of study in investigations such as those by Sánchez-Rodriguez, Palmero and Veja (2017), Rivero-Guerra (2018), and Jensen et al. (2018). It is also essential to investigate how the FC impacts academic performance, how students perceive it, and what they experience in the teaching and learning process mediated by this strategy.

In the health area, research on the flipped classroom in human anatomy has been incipient. Human anatomy is part of a group of basic contents usually present in the first semesters, being a prerequisite for later subjects in health area courses. Although the subject has undergone didactic changes and advanced, it needs renovations in different contexts (Salbego et al., 2015; Foureaux et al., 2018).

Therefore, the central question of this study is: What is the impact of the flipped classroom on the performance of human anatomy students in health courses and their perceptions of their learning process through this strategy? Therefore, the objective was to analyse said impact.

THEORETICAL REFERENCES

Flipped classroom

The flipped classroom (FC) proposes the student's interaction with the introductory material before the face-to-face class to replace direct instruction (also called lecture). With this, it is possible to restructure the face-to-face time, giving it a new purpose, prioritising tasks of the application, analysis, and practice of the content, with the support of the teacher, involving the student in more complex cognitive processes, through group work and individualised attention (Bergmann & Sams, 2014; Bergmann & Sams, 2018).

Sánchez-Rodríguez, Palmero, and Veja (2017) attribute to the FC the vision of a pedagogical approach that changes how students spend their time outside the classroom. In this approach, students are assigned tasks to be carried out during the face-to-face moment, which is restructured, and priority is given to application and creativity tasks. Therefore, they indicate the FC as a rethinking of the study program, in which the professor uses technologies as allies to make his/her role more relevant to the students.

Freitas and colleagues (2021) defend two aspects that make the FC an efficient and attractive approach: the improvement of student autonomy, contributing to an active attitude towards learning, and the rupture of the paradigm with the conventional model, which assigns teachers and students the functions of transmitters and observers, respectively.

Several issues related to flipped classes impact academic performance and students' views of them. Based on evidence from their research, Valente (2014), Sánchez-Rodríguez, Palmero, and Veja (2017), Bergmann and Sams

(2018) and others found promising and adverse factors fostering reflections on the counterpoints and challenges that need in-depth investigations.

One of the positive aspects of the FC is that it allows students to have more choices in their individualised instruction, carrying out the prior study whenever and wherever they want, as long as it is done within the stipulated period (Sánchez-Rodríguez, Palmero & Veja, 2017; Sommer & Ritzhaupt, 2018). Prior contact with the content is advantageous, as it allows for self-paced study and helps prepare for the face-to-face meeting (Valente, 2014).

Sánchez-Rodríguez, Palmero, and Veja (2017) highlight that the FC promotes active learning, encouraging more meaningful activities since the advanced provision of content allows for freeing up face-to-face time, and the students get to class involved in the concepts acquired in the previous lesson. In this same line of thinking, Talbert (2019) believes that extended time in group space is one of the main benefits of flipped learning.

The face-to-face moment can be valuable for the development of active strategies that provide involvement with the content and enable collaborative exchanges. Through flipped classes, teachers can create a more interactive environment, consistent with student-centred learning (Baker, 2000; Talbert, 2019). Inversion enhances the performance of cognitively more advanced tasks in the group space, support from colleagues and the teacher, longer support time in complex work and promotion of self-regulation, developing a set of skills and abilities (Bergmann & Sams, 2018; Talbert, 2019).

The surveys that mention conflicting points and challenges about the FC refer to students, teachers, and the methodology. As for students, one of the drawbacks is that they cannot ask questions immediately in the previous study, so they should receive tips on how to access the material, write down, summarise, and transcribe important points, preparing questions that express their doubts, for later clarification (Bergmann & Sams, 2018; Talbert, 2019).

Lack of motivation can be another inconvenience because, for learning to be effective, students need to be involved. Therefore, we can say that the FC depends on students' motivation and predisposition to perform tasks outside the school environment (Yang, 2017; Sánchez-Rodríguez, Palmero & Veja, 2017; Schmitt & Cequea, 2020).

In FC research with Russian and Finnish teachers, Antonova, Shnai, and Koslova (2017) indicated some barriers that slowed down the implementation of the methodology, such as the time needed to prepare the

material, organisation, and lack of technological support. According to them, the FC requires that teachers receive support in the educational process, which demands creating new functions and participants' engagement.

Those promising and adverse points listed suggest that the implementation of the FC brings potentialities and challenges that require constant research and reflection, which is natural, as it has gained emphasis only recently, and, over time, more investigations will update and elucidate discussions on the topic.

Flipped classroom in human anatomy teaching and learning

Research has been committed to investigating the implications of the FC in teaching and learning human anatomy (Whelan et al., 2016; Enterazi & Juvdan, 2016; Fleagle et al., 2017; Tat et al., 2018; Chapman et al., 2018; Andres et al., 2018; Yang et al., 2020; El Sadik & Al Abdulmonem, 2020).

Enterazi and Juvdan (2016) analysed the FC in human anatomy and physiology, assessing performance and perceptions in LaGuardia Community College, New York. The study provided video classes for prior study and active learning strategies in the face-to-face space (such as "one-minute work", problem solving in groups, and peer instruction). The analyses revealed an improvement in the participants' attitude and confidence, satisfactory retention rate, and 65% to 95% agreed with the effectiveness in their learning and interest.

Whelan et al. (2016) researched two strategies in the teaching of anatomy in medicine at the University of Ottawa: facilitated active learning (FAL) and independent learning (EIL), the second emphasising the FC. EIL participants reported more significant skill enhancement but less efficient learning; EIL (FC) students learned more independently, while in FAL, students learning was more conditioned to the tutor's approach (Whelan et al., 2016).

Another study concerning the FC in human anatomy was carried out by Fleagle et al. (2017) in the medicine course at the University of Iowa. The pre-class materials consisted of 3D videos, dissection instructions, and an anatomical atlas, while integrative activities between the material provided and group tasks of clinical correlations were carried out in the face-to-face stage. Atlas images and 3D anatomy videos were indicated as the most useful

resources for the pre-study; as for learning, the results were modest, with improvements only in the last assessment.

Andrés et al. (2018) investigated the impact of FC on human anatomy in the medical course at Universidad de la Sabana (Colombia) in the module Musculoskeletal System. The students were divided into two groups, one working the upper limb using the FC and the other working the lower limb using the traditional methodology. The results indicated a statistically significant difference for the experimental group, and the authors concluded that the FC helped in discussions, group work, and interactions.

The FC in human anatomy was studied in an integrated way with gamification in Tat et al.'s (2018) research with medical students, seeking to determine whether games correlated to FC affect learning in terms of control, self-efficiency, motivation, and initiative. The students said that participating in the strategy motivated them for self-learning in the pre-class and that the games and review questions in the face-to-face stage provided better engagement.

Such research reports have common points, such as the format of delivery of the previous material through video classes (Enterazi & Juvdan, 2016; Andrés et al., 2018; El Sadik & Al Abdulmonem, 2020), which is usual, although not the only option; and the course, since a good part (Whelan et al., 2016; Fleagle et al., 2017; Andrés et al., 2018; Tat et al., 2018; El Sadik & Al Abdulmonem, 2020; Yang et al., 2020) focused on medicine. Yang et al. (2020) comment that the FC has received attention in medical education, being scarcer in other courses in the health area, such as physiotherapy, biomedicine, and phonoaudiology (speech and sound therapy), among others.

Another similarity between the studies is that they address a growing problem in human anatomy, which is the reduction of working hours, despite the relevance of the subject for health professionals (Whelan et al., 2016; Tat et al., 2018). There is a consensus that the lack of time makes it difficult to cover the different anatomical contents, leaving the face-to-face space overloaded; in this sense, investigating methodologies that allow better use of face-to-face time in human anatomy seems to be emerging.

In this way, the authors (Fleagle et al., 2017; El Sadik & Al Abdulmonem, 2020) agree that the FC is a potential strategy for effective use of face-to-face time in human anatomy, providing an opportunity to deepen the content and compensate for the short workload. However, they suggest the

need for more research on the subject to investigate the best practices that fit the needs of each context (El Sadik & Al Abdulmonem, 2020).

In this sense, the research usually points to promising results, especially regarding the students' acceptance of the methodology, even though at the beginning, there may be some resistance due to the role students must play in this format. However, regarding performance, as argued by El Sadik and Al Abdulmonem (2020), it is still not possible to generalise, as the data are conflicting, mixed, and insufficient, which will undoubtedly raise further debates and investigations.

METHODOLOGY

This article presents data from doctoral research carried out from 2018 to 2021, which had as its object of study the FC in the teaching and learning of human anatomy. It is a case study, and the approach includes the mixed method (Creswell et al., 2011; Dal-Farra & Fetters, 2017), with integrated collection and analysis of quantitative and qualitative data to better understand the phenomenon of study. The mixed-method research applied to this study is convergent, which aims to "compare the results of quantitative data sets [...] with qualitative data", where the numbers can be joined to the explanations of the meanings (Dal-Farra & Fetters, 2017, p. 474).

The research participants were three groups of students attending the Human Anatomy module, coming from several courses in the health area — biomedicine, physical education, biological sciences, aesthetics, and physiotherapy, among others— at a university in the metropolitan region of Porto Alegre/RS. The investigation was divided into two stages: a pilot study (2018/2) and the actual experiment (2019/1 and 2019/2), with the data discussed in this article referring to the actual experiment, with the participation of two 2019 classes (first and second semesters). Regarding the ethical aspects, the project was forwarded via Plataforma Brasil to the Ethics Committee for Research on Human Beings of the university where data collection took place, being approved under CAAE number 00134418.0.0000.5349.

As for the interventions carried out, we chose to elaborate digital hypertexts as pre-class material, built on the Wix Platform and made available by scripts one week before the face-to-face meeting. The hypertexts covered the muscular, circulatory, respiratory, urinary, and genital systems. The tasks in the face-to-face stage consisted of questions about the application of the

contents already mentioned through open questions and association of images with the corresponding anatomical nomenclature, elaboration of virtual mind maps, and practical classes with the construction of digital albums.

Data were collected through questionnaires at different stages of the research, and those presented in this article were obtained in the meetings before and after each flipped class (pre and post-tests) and in a questionnaire at the end of the semester to verify the participants' perceptions. As it is mixed research, part of the questions was closed or on a Likert scale and part open, aiming to obtain subsidies to better understand the quantitative data with the help of the qualitative ones.

The quantitative data were analysed by the scores of the answers and by the statistical test of McNemar, which was used to compare the results between the degree of agreement of the sentences in the pre-test and the post-test; given the assumptions of the tests, we considered $p < 0.05$ as significant. McNemar's statistical test was used to analyse paired nominal data, with the proportions of two samples being related, where the objective is to research the before and after in which each individual is his/her own control. In the test, the nominal scale is used to evaluate changes "after" in relation to the situation "before" or post in relation to pre (Siegel & Castellan, 1981). For the analyses, we used the SPSS (Statistical Package for the Social Science) 23.0 software.

After some of the closed or Likert scale questions, the students needed to justify their answers or marks on the scale, which contributed to the integrated analysis of the data, allowing researchers to verify the justifications for the quantitative answers, expanding the understanding of them and bringing a better understanding of context and meaning. Such qualitative data were analysed based on Bardin's content analysis (2011) and as a corpus the questions and answers of the questionnaires, with an a posteriori categorisation.

RESULTS AND ANALYSES

Academic performance in pre and post-test

To analyse the performance, we applied pre and post-tests consisting of dichotomous questions (phrases with the options "Agree" and "Disagree") referring to the contents worked and a question that presented images to which students should attribute a relationship with the corresponding

anatomical system. For the dichotomous questions, the analysed data are presented in two tables that summarise the statistical significance of the first semester (Table 1) and the second semester (Table 2). Table 1 is shown below:

Table 1

Statistical significance of dichotomous questions, first semester

First semester	Dichotomous questions with statistical significance ($p<0.05$)	Dichotomous questions without statistical significance ($p>0.05$)	p=1	Questions not analysed by the test
Class 1 - muscular system	3	2	0	0
Class 2 - cardiovascular system	2	2	1	1
Class 3 - urinary/genital system	4	2	2	0
Totals	**9**	**6**	**3**	**1**

The data in Table 1 suggests that of the 19 sentences analysed in the first semester by the test, nine presented a statistically significant difference from the pre to the post-test ($p<0.05$); yet, three kept the same frequency (answers did not change, p=1) and one did not allow the application of the test, as it presented only one answer (agree or disagree) in both questionnaires, being impossible to evaluate it by the test. Academic performance in the FC was also researched by Tusa et al. (2018) with medical students from a Finnish university. After comparing the traditional and flipped classes, the results showed statistically significant differences in content and higher average scores for students involved with the FC.

The data of the dichotomous issues of the second term are summarised in Table 2:

Table 2

Statistical significance of dichotomous questions, second school semester

Second semester	Dichotomous questions with statistical significance (p<0.05)	Dichotomous questions without statistical significance (p>0.05)	p=1	Questions not analysed by the test
Class 1 - cardiovascular system	4	0	0	1
Class 2 - respiratory system	1	2	1	1
Class 3 - urinary/genital system	4	2	2	0
Total	9	4	3	2

Table 3

Comparison of the statistical significance of dichotomous questions, first and second semesters

Semester	Dichotomous questions with statistical significance (p<0.05)	Dichotomous questions without statistical significance (p>0.05)	p=1	Questions not analysed by the test
First	9	6	3	1
Second	9	4	3	2
Total	18	10	6	3

Table 2 shows that, of the 18 sentences analysed by the statistical test in the second semester, nine presented a significant difference from the pre to the post-test (p<0.05), three maintained the same frequency of responses (p= 1) and two did not allow the analysis by the test, presenting the same answer in both questionnaires. Based on Tables 1 and 2, it is possible to draw a comparison between the statistical significance observed in the test applied to

the dichotomous questions of the first and second semesters, expressed in Table 3:

According to Table 3, of the 37 dichotomous sentences analysed, 18 obtained a statistically significant difference in the post-test ($p<0.05$), six maintained the frequency of response ($p=1$), and three could not be analysed by the test. Therefore, there is an improvement in performance through the intervention performed (FC). Other studies sought to elucidate academic performance when in the FC in a human anatomy module, such as Yang et al.'s (2020), conducted with medical students from a Chinese university. In their study, the statistical differences from pre to post-test were significant, and the perceptions revealed interest in the anatomical study mediated by the strategy. For the authors, the effects of the FC were promising in anatomical education, favouring more efficacious and convenient teaching for the subject matter.

El Sadik and Al Abdulmonem (2020) researched FC in the medicine course at a university in Saudi Arabia, seeking to determine the result of the flipping based on the student's level of cognition in the study of the theme Musculoskeletal system. The results suggested a positive impact on improving their thinking levels. The opinions revealed enthusiasm for pre-class tasks, leading to better face-to-face performance and peer engagement. Flipped learning promotes the development of competencies and self-regulation, as it requires more than transferring information, and prioritising strategies that mobilise greater cognitive load, leading to deep learning (Talbert, 2019).

As for the data obtained by analysing the association of images with the anatomical systems, Table 4 presents a general overview that reveals the images that showed a percentage increase of association (as very related to that system):

The data in Table 4 reinforce that, for all the flipped classes of the experiment carried out, the percentage increase referring to the association of images to the systems was consistent with the anatomical system studied, which indicates a sharper visual perception after the completion of the flipped classes on the content. From the data discussed in this section, we infer that the flipped strategy culminated in advances in academic performance, despite some limitations reported by the participants, such as the persistence of doubts and/or misconceptions.

Table 4

Images with a percentage increase of association with the appropriate systems studied, pre and post-test

Class/theme	Image	Pre-test (n and %)	Post-test (n and %)
Class 1 – Muscular system		8 33.3%	21 87.5%
Class 2 – Circulatory system		3 14.2%	12 57.1%
Class 3 – Urinary and genital systems		12 52.1%	17 73.9%
Class 4 – Circulatory system		4 26.6%	9 60.0%
Class 5 – Respiratory system	a)  b) 	a) 5 b) 3 38.4% 23.1%	a) 11 b) 9 84.6% 69.2%
Class 6 - Urinary and genital systems		10 66.6%	14 93.3%

Undergraduates' perceptions of the flipped classroom in their learning

Foureaux et al. (2018) emphasise that investigating students' perceptions is as important as evaluating their performance, because the feedback contributes to enhancing teaching strategies. The first question was about students' perceptions. They had to check on a four-point scale between "Strongly disagree" and "Strongly agree" to give their level of understanding

of the topic studied (muscular, circulatory, respiratory, urinary and genital systems) in the flipped class. The answers are shown in Figure 1.

Figure 1

Understanding of the contents studied, according to the students' perception, per class

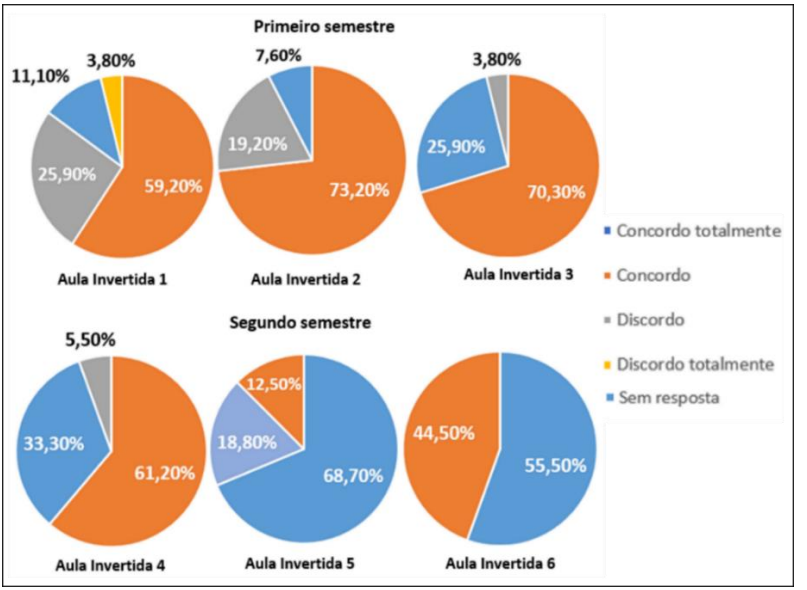

Figure 1 shows that, by comparing the answers, the second-semester group agreed more than the first-semester group. It also indicates that, during the flipped classes, the understanding of the content becomes more satisfactory, which can be observed by comparing the disagreements of the first-semester classes, where the percentages for the options "I totally disagree" and "I disagree" decreased during the classes.

In the study by González-Gómez et al. (2017), at the University of Extremadura, students enrolled in the school subject Didactics of Matter and Energy were asked how they perceived their learning after the flipped classes. The score in the control group was 2.98, and in the experimental group (with the flipped classes), it was 4.12 (scale from 1 to 5). For the authors, it means

that the participants perceived the flipped approach in a more satisfactory way than in a traditional approach.

In the next question, the students were asked to record the aspects of each flipped class that helped to learn the content. For this question, the data were presented in two tables, one for the first and the other for the second semester. In Tables 5 and 6, the total number of respondents is considered to be those who attended the three classes. Table 5 shows the categorisation for classes one, two, and three.

Table 5

FC assistance in the first semester flipped classes

CATEGORY	PRIMARIES SUBCAT.	SECONDARIES SUBCAT.	f	ANSWERS (%)
FC assistance in the study of muscular, circulatory, and urinary/genital systems	Materials made available/ material aid	Visual aid/images/location of structures	18	14.0
		Adequate/complete/easy-to-understand material	7	5.6
		Tablets/internet	7	5.6
		Videos	6	4.8
		Use of TD/3D material, animations/applications	6	4.8
		Material drawings/dynamics	4	3.2
		Study support for assessments/learning	3	2.4
		Pre-class texts	2	1.6
	Pre-class and face-to-face activities	Face-to-face stage helped/was essential/deepened the online study/ clarified doubts	10	8.1
		Preliminary study: first contact with the theme/theoretical basis to clarify doubts	9	7.1
		Opportunity to study before class	3	2.4
		I liked the two stages / It was good	3	2.4

		Understanding/relation of the contents studied (circulation/heart/muscles)	2	1.6
		Objective and easy to understand/study for exams	1	1.0
		More time to study	1	1.0
		Pay more attention	1	1.0
		Insistence of exercises on specific structures	1	1.0
	Challenges faced	Little time for assignments/lots of content for a class	8	6.4
		Difficult task/Doubts	5	4.1
		Lack of content exposure	3	2.4
		Many things were not seen / further reading	2	1.6
		Application usage	1	1.0
	Memorising/Name and location of structures		10	8.1
			3	2.4
	Human interactions	Debating/help from colleagues was productive, dynamic		
		Teacher help/explanations	3	2.4
		Answer questions	2	1.6
	No answer		3	2.4
Total			124	100

The primary subcategories that stood out were “Materials made available/material aid”, “Pre-class and face-to-face activities”, and “Memorising/name and location of structures”. Human interactions were also highlighted, focusing on help and debates between peers and teachers.

Regarding the material, the most prominent secondary subcategories were the visual aid, its suitability, and the use of tablets and the internet (18, seven, and seven mentions, respectively). As for the activities, the emphasis was on the face-to-face/group assistance to deepen the study and the pre-class assistance. The primary subcategory “Memorising/name and location of structures” was another point highlighted regarding the contribution to

understanding and deepening the knowledge of the anatomical structures of the human body, especially in terms of nomenclature and location. In the health sciences, some disciplines focus on terminology, and many include the necessary memorisation of structures; therefore, memorisation tasks are expected among the face-to-face activities of these components (Talbert, 2019).

Despite the favourable points, some difficulties were mentioned, such as "Little time for tasks/too much content for a class", "Difficult task/doubts" and "Lack of content exposure". In Fleagle et al.'s (2017) study, participants expressed that the level of difficulty of the tasks may have been high for recently learned content. Given the difficulties listed, it is relevant to emphasise that flipped learning is as challenging as other approaches. One of the challenges is the change in the student role because, in the traditional context, it is common to assign students the position of listeners who perform tasks after the face-to-face meeting. This position generally makes them more confident, as they are used to performing it. Therefore, they may initially dislike the new role assigned to them in flipped learning, and changing to adapt can take time and effort (Talbert, 2019).

As for the difficulties in the tasks, according to some participants, they may be related to the active role assigned to the student in application activities, since it requires a greater cognitive load than just listening and taking notes. At first, this may lead the student to believe that this approach is not suited to their learning style; therefore, the difficulty should not be seen as a complaint but associated with the greater efforts needed (Talbert, 2019).

The answers categorised for the second-semester classes, referring to the circulatory, respiratory, and urinary/genital systems, are represented in Table 6:

Examining Table 6, we see that some primary subcategories that stood out for the second-semester classes were similar to those of the first, such as "Pre-class and face-to-face activities", "Materials made available/material aid", and "Human interactions". Among the topics related to the activities, the most prominent secondary subcategories indicated that they deepened and clarified the knowledge of the systems and structures studied (17 mentions) and that the face-to-face stage was significant for understanding the contents (six mentions).

Table 6

SAI assistance in the first semester flipped classes

CATEGORY	PRIMARY SUBCAT.	SECONDARY SUBCAT.	f	ANSWERS (%)
The assistance of the FC in the study of circulatory, respiratory, and urinary/genital systems	Pre-class and face-to-face activities	Deepened/clarified knowledge of systems and structures	17	23,3
		Significant/didactic /interactive face-to-face stage helped in understanding	6	8,2
		Pre-study/preparation for class	3	4,1
		Two-stage class is good for clearing up doubts	3	4,1
		Incentive to research	2	2,7
		Face-to-face stage with technology was easier to learn	1	1,4
		All very useful	1	1,4
		Changed study mode for future subjects/exams	1	1,4
	Materials made available / material aid	Didactic/complete/ easy to understand/clear and appropriate	12	16,5
		Videos	7	9,6
		Images/visual aid	5	6,8
		Questions/questionnaires/texts	5	6,8
		Tablets/Technological material	2	2,7
		Mental maps	1	1,4
		Links	1	1,4
	Difficulties found	Access to prior study	1	1,4

		Lack of content disclosure	1	1,4
	Human interactions	Interactions between colleagues	2	2,7
	No answer		2	2,7
Totals			**73**	**100**

Regarding the materials made available in the pre-class, they were characterised as didactic, complete, easy to understand and suitable (12 mentions), with emphasis on videos, images, and questions/texts (seven, five, and five mentions, respectively). Those data reinforce the participants' position that the study materials contributed to their learning in flipped classes. On materials for study in FCs, Junior (2019) emphasises the need to organise and select activities suited to each audience, as it consists of different planning from a traditional class. So, they must be in clear language, using various resources, such as texts, audio, videos, animations, and simulations.

Although less frequently, human interactions were present among the answers of the second group, showing recognition for the help given to colleagues and teachers in face-to-face tasks carried out in groups. According to Talbert (2019), the satisfactory use of face-to-face time is one of the main points of flipped learning, which is when students and faculty can share, benefiting from this proximity. The secondary subcategory, "Changed the way of studying for future subjects/exams" indicates, as advocated by Yang (2017), that FC fosters skills to be transferred to other courses or situations in the future. "Incentive to research" is equally significant, as FC practices aim to encourage the search for knowledge in an autonomous way.

Besides those favourable points, some difficulties were mentioned, but with less emphasis than in the previous group, such as "Access to the previous study" and "Lack of content exposure", the latter being repeated in both groups. Less centrality in the lecture is one of the characteristics of flipped learning; the lecture does not necessarily have to be avoided; however, it has a different space and objectives, so small exposures related to specific doubts are welcome (Talbert, 2019).

Using a five-point Likert scale question (Strongly Agree to Totally Disagree), participants were asked whether the flipped classes contributed to learning. Their answers are in Figure 2:

Figure 2

FC's contribution to learning

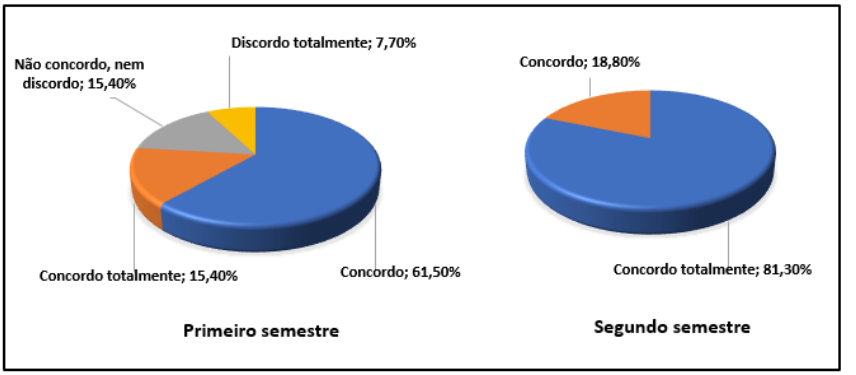

Figure 2 corroborates the participants' position, with a greater agreement regarding the FC's aid for learning in the second-semester class (81.3% totally agree and 18.8% agree); in the first semester, the majority (61.5% and 15.4%) agreed. Therefore, we infer that most participants believe that the flipped classes helped their learning of human anatomy.

In Pavanelo and Lima's (2017) research, the students assigned the FC 8.4 points (on a scale from 0 to 10), which meant, for the authors, a high level of satisfaction with this form of work. Sommer and Ritzhaupt (2018) found in their investigation with students from the University of Florida a statistically significant difference in satisfaction in favour of the group that did not use the flipped approach, which suggests that it is not always indicated as students' preference.

To deepen the understanding of the position regarding the contribution of FC to learning, academics should justify their answers (referring to the data in Figure 2); the justifications were categorised in Table 7:

Given the agreement justifications presented in Table 7, both groups share two main aspects: the secondary subcategories "Prior understanding of the content" and "Preparation/time and complete contents"; in addition, "Assistance from the material available" and "Easy-to-understand contents/activities" stand out. Prior preparation is one of the essential stages of the FC and, according to Valente (2014), this previous contact of the

student with the material has several benefits, such as working at his own pace, deepening knowledge, encouraging preparation for the class and making use of more significant than face-to-face time. Regarding material aid, as highlighted by Sánchéz-Rodríguez et al. (2017), it must be adapted according to the subject matter, and, in the case of this research, it was one of the factors the students emphasised.

Table 7

FC contributions to learning, justifications

CATEGORY	SUBCAT. PRIMARIES	SUBCAT. SECONDARIES	f	ANSWERS (%)	STUDENTS (%)
		First semester			
Contribution of the flipped classroom to learning	Totally agree	Activities, exercise theory	1	7.7	7.7
		Content reinforcement	1	7.7	7.7
	Agree	Support from the material available/images/schemes	3	23.1	23.1
		Prior understanding of content	2	15.3	15.3
		Interesting methodology	1	7.7	7.7
		Assistance with the activities	1	7.7	7.7
		Added to the studies	1	7.7	7.7
	Neither agree nor disagree	Contradictory information	1	7.7	7.7
		Difficulties, prefers face-to-face classes	1	7.7	7.7
	Strongly disagree	Only skimmed content	1	7.7	7.7
Totals			13	100	-
		Second semester			
Contribution of the flipped classroom to learning	Totally agree	Easy-to-understand content/activities	2	12.8	12.8
		Prior preparation/time and complete contents	2	12.8	12.8
		Provided good materials	1	6.2	6.2
		Few exercises	1	6.2	6.2
		Very effective methodology	1	6.2	6.2
		Allows student participation	1	6.2	6.2

		Allows students to learn in a different and interesting way	1	6.2	6.2
		They were productive and thought-provoking	1	6.2	6.2
		Opportunity to research	1	6.2	6.2
		It was complementary	1	6.2	6.2
		Without justification	1	6.2	6.2
	Agree	Peer interactions and activities helped understand	1	6.2	6.2
		Easier to understand	1	6.2	6.2
		Good materials, but difficult to carry out all the previous studies	1	6.2	6.2
Totals			16	100	-

Regarding the points of disagreement, they were mentioned in the first semester and justified by difficulties encountered and the view that the content was overlooked, expressing the relationship of the study to the amount of information transmitted. For Talbert (2019), some students find difficulties in flipped learning due to the lack of lectures, as they bring the conception of their role as listeners and that of the teacher as a transmitter. From this perspective, implementing FC demands a transformation, delegating the central role to the student and the mediation to the teacher.

Some of the students' full answers are listed below and contribute to elucidating their perceptions:

> *I found the methodology of the flipped class interesting, but I still prefer to go to the classroom and listen to the teacher's explanation and solve exercises at home (Student 2, first semester).*
>
> *I agree, because the activities carried out during the flipped classes made me consult the content both in the classroom environment and on the tablet, and with that I was learning it while doing the activities (Student 9, first semester).*
>
> *The classes contributed to learning, but they alone are not enough, as most students work during the day and study at night and it is often difficult to study all the content available, it would be amazing if that were possible, but this is not*

> *reality, but the materials prepared are very good (Student 4, second semester).*
>
> *In flipped classes, we had to research, and this, in my opinion, is one of the best ways to build knowledge (Student 14, second semester).*

Comparing the answers of students 2 and 9, we noted that the first was passive, while the second had greater importance; in student 14's speech, we identified an open attitude open toward the construction of knowledge through investigation, through active research. In turn, student 4's speech exposes a situation shared by a significant portion of the students of the institution where the research was carried out, that the division of time between work and academic activities reduces the time available for studying. This problem is also addressed by Salbego et al. (2015), who found that a significant portion of students develops activities parallel to academic life, reducing the period they dedicate to studies.

CONSIDERATIONS

Blended learning has been highlighted as promising today, also driven by the educational implications arising from the Covid-19 pandemic. One of the sustained modalities of blended learning is the FC, which places this strategy at the centre of debates and discussions.

One discipline in which research on flipped classes is incipient is human anatomy. Therefore, the central question of this study is: What is the impact of the FC on the performance of human anatomy students in health courses and their perceptions of their learning process through this strategy?

As for performance, the data showed statistical significance between the dichotomous questions from pre to post-test in both groups. Of the 37 sentences analysed, 18 obtained a statistically significant difference in the post-test; six maintained the response frequency and three were not compared, as they had only one response (agree or disagree) in both questionnaires. We infer, therefore, that there was an advance in performance through the intervention performed (FC).

The students' perceptions are in accordance with this result, as both groups agree that FC helps learning, with a total percentage of agreement (100%) in the second semester and 76.9% in the first. We also observed that

the perceptions regarding the understanding of the content became more satisfactory as the classes went on.

Given the analysed data, this study presents the students' perceptions of a flipped class for teaching and learning Human Anatomy and analyses their performance in this strategy. Such results are relevant due to the need to investigate didactic possibilities for the study of this subject matter, which, despite having a vast repertoire of contents that are of such importance for health professionals, suffers from the reduced classroom workload.

Thus, we recommend that more research be developed to investigate the performance and perceptions of human anatomy students using flipped classroom methodology in different contexts, considering the plurality of educational realities to seek evidence about the implications of this modality in teaching and learning this subject matter.

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AUTHORSHIP CONTRIBUTION STATEMENT

This article was prepared and organised by two authors. C.M.B.S. was responsible for constructing theoretical and methodological contributions, data collection, analysis and discussion. P.T.C.L. guided and supervised the project, and revised and corrected the analysis and the writing of the article.

DATA AVAILABILITY STATEMENT

The authors agree to make data supporting the results of this study available upon a reasonable request from a reader, and it is up to the authors to determine whether or not a request is reasonable.

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