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The role of asynchronous and synchronous activities in university academic performance: A comparative study of traditional and inverted class methodologies

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Abstract

Purpose: The objective of this work is to investigate the effect of synchronous and asynchronous activities on the academic performance of university students. For this purpose, the academic results obtained and the involvement and motivation of the student and the teacher in the different learning methodologies involved are analyzed. Students' perception of the effectiveness of the flipped class with the face-to-face classroom and online methodologies is compared to that of the traditional learning methodology.

Design/methodology: Data were collected from undergraduate students in three marketing courses and were analyzed through a quantitative descriptive, quasi-experimental and cross-sectional study. Academic performance with the different learning methodologies and the effect of synchronous and asynchronous activities on academic performance were compared using logistic regression on each course and methodology.

Findings: The results showed that academic performance in synchronous and asynchronous activities was better in the flipped class, except for synchronous activities in the online flipped class. In addition, the best academic performance was obtained in the face-to-face inverted classes. The explanatory effect of asynchronous activities on academic performance was also identified. The greatest predictive capacity and the best prognosis were obtained in the online inverted classes. Students expect to obtain satisfactory results with the inverted class methodology and perceive it as effective, although they prefer a mixture of inverted classes and the traditional methodology.

Originality/value: We contribute to theoretical and practical research with this new model to study the influence of the flipped learning methodology and asynchronous and synchronous activities on academic performance. We believe that these results, despite the specific and limited scope of the study, will be of great interest to the teaching community and contribute to improving the motivation and performance of students, which constitutes a main challenge in the higher education system.

Keywords: Inverted Class, Flipped learning, Synchronous, Asynchronous, Teaching innovation, Academic performance

Jel Codes: A22, M30, O32, I20

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1. Introduction

In the majority of higher education institutions, the health crisis caused by COVID-19 accelerated the application of new educational methodologies that facilitate the teaching and learning process in the face of public health crises. These methodologies involve new didactic strategies that ensure interaction between teachers and students both in the classroom and remotely or online. The present work is based on the implementation of an active teaching-learning methodology that makes the student the protagonist of his or her learning, thus consolidating the acquisition of theoretical-practical knowledge. Therefore, this study is driven partly by the motivation of the teachers responsible for providing instruction on Communication Policy and Digital Advertising in a Marketing degree program, who were tasked with facilitating student learning on a continuous basis through synchronous (SY) and asynchronous (AS) activities. The knowledge acquired by students concerning the fundamental concepts of commercial communication and digital advertising strategy was evaluated for cases in which they learned about the subject through the flipped class (FL) method and in a traditional classroom.

Thus, part of the justification of this study is teachers' motivation to solve the challenge of facilitating the work process and student learning while remaining in a constant relationship with them through the facilitation of SY and AS activities. The study aims to evaluate students' academic performance (AP) and the knowledge acquired on the fundamental concepts taught and to compare the results when they learned about the subject through the flipped class method (physical and online)versus in a traditional classroom.

The importance of the use of information and communication technologies (ICTs) at all levels of education is reflected in the aid objectives of UNESCO (2018) based on "Taking Advantage of ICT to Achieve the Goals of Education 2030". To meet these objectives, UNESCO committed to providing participating member states with the necessary documentation and best practices in the use of the necessary tools in education, paying special attention to innovations within the digital environment.

With the same aim, the present study of teaching innovation was carried out with a teaching-learning model based on the flipped classroom. The term "FLIP" is an acronym that encompasses the pillars on which this method is based: Flexible Environment, Learning Culture, Intentional Content and Professional Educator (Yarbro, Arfstrom, McKnight & McKnight, 2014). Subsequently, other authors added three letters to this acronym, using the adjective "FLIPPED" (Chen, Wang, Kinskuk & Chen, 2014) to encompass three additional pillars: progressive activities, attractive experiences, and diversified platforms.

The relevance and validity of this inverted class model is demonstrated by the large volume of publications during the past decade (Sola Martínez, Aznar Díaz, Romero Rodríguez & Rodríguez-García, 2018; Wang, 2019; González-Velasco, Feito-Ruiz, González-Fernández, Álvarez-Arenal & Sarmiento-Alonso, 2021; Tekin, Ilgaz, Afacan, Yıldırım & Gülbahar, 2020; Oliván-Blázquez et al., 2022; Cueva & Inga, 2022; Ishartono, Nurcahyo, Waluyo, Prayitno & Hanifah, 2022; Felgueras & Delgado, 2021; Alyoussef, 2021; Limaymanta, Apaza-Tapia, Vidal & Gregorio-Chaviano, 2021; among others).

The flipped class is a learning alternative where the traditional elements and tasks of a course are reversed. Thus, before class, students receive the content, in the form of mainly videos, which they must then assimilate and study. Subsequently, during class, students perform scheduled learning activities, and the teacher acts as a guide to assist them in consolidating their learning (González-Velasco et al., 2021). This approach combines constructivist ideology and behavioral principles that can be used to reduce the gap between didactic education and practical performance (Hawks, 2014).

The efficacy of this inverted class methodology has been studied in different higher education environments, especially in areas such as biomedical sciences (McLaughlin et al, 2013; Baepler, Walker & Driessen, 2014; Chen, Lui, & Martinelli, 2017; Njie-Carr, Ludeman, Lee, Dordunoo, Trocky & Jenkins, 2017; Wu, Chi, Wu & Kang, 2018), social sciences (Albert & Beatty, 2014; Roach, 2014), language teaching (Adnan, 2017; Lee & Wallace, 2018) and social work (Gómez-Poyato, Aguilar-Latorre, Martínez-Pecharromán, Magallón-Botaya & Oliván-Blázquez, 2020; Holmes, Tracy, Painter, Oestreich & Park, 2015; Oliván Blázquez et al., 2022). However, within the social sciences where this research is framed, literature on the impact of this method on grades and the

perception of students is extremely limited. On the one hand, the work of Albert and Beatty (2014) analyzed the effect of the flipped class on the AP of university students foran Introduction to Management course. Students who learned the subject through the flipped class method obtained a significantly higher performance than students who acquired the knowledge through a traditional face-to-face class format. On the other hand, Roach (2014) analyzed the perception of students toward learning microeconomics through the flipped class. This author found that students responded positively to this methodology and identified that this instructional design benefitted all groups of students examined. Therefore, the current research aims to expand knowledge on the influence of the inverted and traditional class methods on students' performance, perception, and preferences. It makes an original contribution through its study of the possible impact of different types of assessment activities (AS and SY) and the teaching modality (face-to-face and online).

The advantages of the flipped class include the following: 1) student motivation; 2) the development of students' competence in debate, which improves due to having the subject content before class and preparation; and 3) students' participation and their focus on the tasks in class and not on the teachers, who act as facilitators rather than lecturers (Halili & Zainuddin, 2015). Likewise, student assessment with the methodology is positive and satisfactory, achieving a positive change in students' attitude toward learning. However, this method also has disadvantages, as it is a relatively new model to which not all teachers and students are able to adapt (Al-Zahrani , 2015).

Few studies have examined the relationship between the activities carried out in the classroom in an SY and AS manner, which can clarify the impact of these methods on AP. Accordingly, this study aims to determine the influence of the teaching methodology of the flipped class on the AP of university students, focusing on students enrolled in the Marketing degree program. This research is based on a quantitative descriptive, quasi-experimental and cross-sectional study that compares the AP of students from three courses through logistic regressions. To this end, the effect of factors such as AS and SY assessment activities, the traditional and flipped class teaching method and the face-to-face and online modality on students' learning were analyzed. Additionally, a second descriptive analysis was included to discover the assessment and preferences of students with respect to the didactic methodology.

The results highlight that students who learn through the flipped class methodology obtain better grades in AS activities than those who learn with traditional methodology. The best AP in both AS and SY activities was found in students in the face-to-face flipped class. With respect to the type of activities, the predictive capacity of AS activities for the performance of the three courses was identified. Finally, the students surveyed in this study perceived the flipped class methodology as effective and hoped to achieve good results with it. In order of preference, they preferred the mixed methodology, followed by the inverted class and the traditional class.

Following this introduction, the present work is structured into the following sections. In the second section, the background, conceptual model, and research hypotheses to be contrasted are presented. The third section describes the various phases of the methodological design, the sample used, the data sources, and the procedure used to analyze the information. The fourth section shows the results obtained and their interpretation. Finally, the last section presents the discussion and conclusions.

2. Background and conceptual model

2.1. Differences between the inverted and traditional class methodology

The predominant instructional model in higher education continues to be the traditional model based on lectures by teachers (González-Velasco et al., 2021). However, in this methodology, students play a passive role that is detrimental to their motivation and training. Therefore, some authors describe this model in terms of only teaching and not learning because it stimulates mechanical and rote learning of knowledge. This passive learning approach neglects not only the need to improve how to learn but also the processes, cognitive aspects and external factors associated with learning (Vinent, 2009).

Active learning methodologies allow students to acquire knowledge through practice, promoting their retention of the knowledge learned and their understanding of its applicability in real life and their professional futures (González-Velasco et al., 2021). In this context, at the end of the 1990s, the inverted class methodology (FL)

emerged, which, together with the evolution and use of new technologies at the time, offered different learning opportunities (Lage, Platt & Treglia, 2000).

Thus, the flipped classroom model allows students to access and study course materials (for example, with content summaries, presentations, videos) before the classroom sessions (Chyr, Shen, Chiang, Lin & Tsia, 2017), providing free access to course content, with flexibility regarding the time and place of learning that best suits his or her needs (Tekin et al., 2020). In this manner, students' newly acquired knowledge allows them to participate in class by studying, solving problems, advancing their understanding of theoretical concepts, and conducting collaborative work (Tucker, 2012).

In the flipped class methodology, the main function of the instructor is to act as a guide in the teaching-learning process, while the students assume an active role in assimilating the information and contributing new ideas (Bennett et al., 2013; Chen et al., 2018). In this manner, the purpose of the method is to encourage the student to become involved and to participate in ways that optimize class time (Mendaña-Cuervo & López-González, 2021; Basso-Aranguiz, Bravo-Molina, Castro-Riquelme & Moraga-Contreras, 2018). In addition, FL facilitates active learning and problem solving (Galway, Corbett, Takaro, Tairyan & Frank, 2014). Consequently, this system demands great perseverance, willpower, good study habits and a higher level of effort than that required in the traditional system (García, Traver & Candela, 2001). Likewise, this modality allows the teacher to dedicate more time to interaction, to the improvement of critical thinking and to the enrichment of class sessions, thus engaging with the teaching-learning process in an interactive manner(Campbell, Cabrera, Ostrow Michel & Patel, 2017).

Through the use of ICT, the FL modelenables the promotion of constructivist learning, which facilitates the realization of interactive activities. In addition, it allows the teacher to select a topic, propose objectives, prepare digital resources, prepare questionnaires, and distribute materials to students (Cueva & Inga, 2022).

2.2. The relationship between the inverted class model and academic results

In the context of university education, continuous and summative formative assessment is applied. In the formative assessment, the student is considered a subject in constant development who is progressively and continuously monitored during the course (Black & Wiliam, 2018). In addition, formative assessment is complementary to summative assessment, which determines the mastery and quality of students' knowledge on a set of topics (Buchholtz, Krosanke, Orschulik & Vorhölter, 2018).

Numerous studies have analyzed the academic results of students obtained from the use of the FL methodology (Espada, Rocu, Navia & Gómez-López, 2020; Rivero-Guerra, 2019; Bishop & Verleger, 2013). The findings of these studies demonstrate a positive effect on AP. These studies evaluate performance quantitatively through students' grades, which are significantly higher than those achieved with traditional and mixed methodologies. However, Rivero-Guerra (2019) stated that the cooperative and autonomous learning strategies of students are still in the initial phase of development. For this reason, in this research, we analyze whether the didactic method used by the teacher significantly influences the AP of students, and we thus propose hypotheses (H1) and (H2).

> *H1: There are significant differences in the grades of AS and SY activities between the online flipped classroom (OFCC) methodology and face-to-face flipped classroom (FFCC) methodology and the traditional classroom (CTFM) methodology.*
>
> *H2: The qualifications of AS and SY activities with the OFCC and FFCC methodologies are higher than those of the course with the CTFM methodology.*
>
> > *H2a: The grades obtained through AS activities with the OFCC and FFCC are higher than those obtained with the CTFM.*
> >
> > *H2b: The scores obtained on SY activities with the OFCC and FFCC methodologies are higher than those obtained on SY activities with the CTFM methodology.*

The objective of these first two hypotheses is to evaluate and identify the possible differences between the influence of the traditional pedagogical model and FL on the results obtained by students in the SY and AS activities carried out with the purpose of improving the quality of their learning and encouraging their motivation.

2.3. The difference between synchronous and asynchronous evaluation activities

One of the main priorities of educational institutions today is to facilitate the acquisition of knowledge both inside and outside the classroom (Huang, Chou, Leu, You, Tiao, & Chn, 2020).

The new teaching methodologies in the classroom are supported by the implementation of ICTs since they meets needs inside and outside the classroom through classroom and online activities (González-Gómez, Jeong, & Airado Rodríguez, 2016). It is a pedagogical model in which students access digital resources that the teacher shares through a platform external to the classroom (Bergmann & Sams, (2012) with varied content such as prerecorded lectures, selected readings, study guides, interactive videos, simulations and cases, and classroom activities such as interactive participation, just-in-time teaching, and peer instruction (Berrett, 2012). In this manner, the model can be applied to student tasks before, during and after class (Salas-Rueda, 2021) and synchronously and asynchronously. In SY activities, the student develops them while interacting with the teacher, while AS activities lack such interaction. Likewise, this interaction can occur online or in person (Lapitan, Tiangco, Sumalinog, Sabarillo & Diaz, 2021; Young, Bailey, Guptill, Thorp & Thomas., 2014).

Most published studies on the influence of the combined use of the FL method with ICTs on the AP of students have found positive results. These effects include how ICTs increase communication between teachers and students (Stöhr, Demazière, & Adawi, 2020), develop technological skills at an early age and encourage group work (Koh, 2020; Leiva, Ugalde Meza & Llorente-Cejudo, 2018). Likewise, FL and ICTs help teachers conducta more personalized follow-up with students and reinforce the learning of subjects that require additional time for activities (Jin & Harp, 2020), depending on the learning pace of the students (Cueva & Inga, 2022). For all the above reasons, this learning method and strategy based on the use of ICTs benefits the teaching and learning process in a collaborative manner and is recommended for both SY and AS environments (Wen, Zaid & Harun, 2016).

Therefore, in this research, the following study hypotheses (H3) are proposed to measure whether there is a relationship between the results obtained from AS and SY activities in the AP of students based on the learning methodology used by the teacher. In addition, hypothesis (H4) seeks to determine whether there is a positive and significant influence of AS and SY activities on the AP of the students under the different methodologies.

> *H3: There is a significant and positive relationship between grades on AS and SY activities and between these grades and the total grade, both with the CTFM methodology and with the OFCC and FFCC methodologies.*
>
> *H4: Grades on AS and SY activities have a significant and positive influence on the AP of students in both the CTFM methodology and the OFCC and FFCC methodologies.*
>
> > *H4a: The grades on AS activities have a significant and positive influence on the AP of students in both the CTFM methodology and the OFCC and FFCC methodologies.*
> >
> > *H4b: The scores on SY activities have a significant and positive influence on the AP of students in both the CTFM methodology and the OFCC and FFCC methodologies.*

2.4. Perception and preferences regarding the flipped class

The effectiveness of a methodology to improve learning is measured in most studies through the numerical grade obtained by students. However, other approaches propose using different indicators to evaluate performance, such as the perceptions of students regarding the use of FL (Gutiérrez-Monsalve, Garzón & Segura-Cardona, 2021). Duque (2014) stated that the perceptions of students are strongly related to general satisfaction with the course. Likewise, with the use of active teaching methodologies, a change is achieved in terms of students' positive attitudes, which is appreciated in aspects such as class attendance, participation, commitment, involvement, and motivation (Saglam & Arslan, 2018; Zheng, Bhagat, Zhen & Zhang., 2020). Therefore, within this inverted learning environment, as indicated by Ruiz-Jiménez, Martínez-Jiménez, Licerán-Gutiérrez and García-Martí (2022), formative assessment and students' best attitudes have a positive effect on academic results.

However, after carrying out a bibliographic review, we found a scarcity of published works on the perception of students regarding the use of the FL methodology (Garnjost & Brown, 2018; Tekin et al., 2020). To compensate

for this lack of research, this study asks whether students' perception of the inverted class methodology is positive (H5).

> *H5: Students' perception of the flipped class methodology is positive regardless of whether the modality is delivered online with the OFCC or delivered in person with the FFCC.*

In terms of students' preferences regarding the teaching methodology, despite belonging to the generation of digital natives and rapidly adapting to online classes, contemporary students prefer human interaction, even in online classes. In fact, AS activities without human interaction are not as effective (Lo, Cheung, Chan & Chau, 2021). Similarly, students prefer to receive course content through exposure to a teacher in the classroom in the traditional teaching-learning process (Cavazos, 2018).

Previous research underscores how the ease of using digital tools influences the positive or negative perception of students toward the applied methodology (Tsai, Hwang, Tsai, Hung & Huang, 2012). Likewise, regarding the instruments used in teaching with the FL methodology, previous studies conclude that, although students prefer face-to-face classes to video classes, they also like audiovisual classes because they are shorter (Bishop & Verleger, 2013). However, these authors stated that future experiences and more consistently applied research are necessary to obtain more solid conclusions. To deepen knowledge about the assessment of the students in this regard, the following hypothesis is proposed (H6).

> *H6: Students prefer the FFCC methodology over the traditional classroom methodology (H6a), and they consider it more effective than the traditional classroom methodology (H6b).*

3. Methods

3.1. Research design

This research was designed through a descriptive, quasi-experimental and cross-sectional study in which the AP of the students was analyzed with AS and SY assessment activities. Additionally, the opinions of the students regarding the flipped class model and their preferences between this methodology and the traditional methodology were collected.

3.2. Experimental design and sample

A sample of 223 students studying Communication Policy and Digital Advertising in the Marketing degree program at Rey Juan Carlos University was obtained; 94 students were enrolled in the 2019/2020 course (CTFM), 63 were enrolled in the 2020/2021 course (OFCC), and 66 were enrolled in the 2021/2022 (FFCC) course. The sample included only students who completed the final exam, as it is a mandatory requirement for passing the course. For the CTFM and OFCC courses, ordinary and extraordinary calls were considered, while only ordinary calls were considered for the FFCC. Students' grades were obtained from academic records (secondary data sources). The sample is non probabilistic and directed since three independent groups are established in the experiment.

The course was taught in the first semester of each year for four months, four hours per week. The learning methodologies applied in the courses were different. In the 2019/2020 course (CTFM), the traditional methodology was used in person using technologies in LMS environments (the learning management system); in the 2020/2021 course (OFCC), the FL methodology was applied online; and in the 2021/2022 (FFCC) course, the implementation of the FL methodology was maintained but in a completely face-to-face format.

In the CTFM group, with traditional and face-to-face methodologies, the classes were adapted using ICT resources, tools such as Moodle, Kahoot, videos, and material prepared by the teacher. To reinforce student learning, 12 group and individual SY activities were carried out through competitions, tests, debates, and student presentations. In addition, 17 group and individual AS activities were carried out, such as forums, self-assessment tasks, self-assessment tests, and case studies of advertising campaigns. In total, 29 evaluative activities were used in the course.

In the OFCC group, with the FL methodology, the classes were taught entirely online, and interactive SY and AS activities were created. These activities were developed before, during and after class (Salas-Rueda, 2021). The

activities that were carried out before were AS activities, with the intention of preparing the student for the theoretical and practical parts of the course.For this reason, with the OFCC group, the didactic materials were transformed into interactive materials, incorporating workshops, and reinforcing the preparation activities with digital tools of institutional access, such as Wooclap, H5P and Genially. The SY activities that were conducted during the classes were designed to consolidate knowledge through individual and collaborative work (see the example in Figure 1).

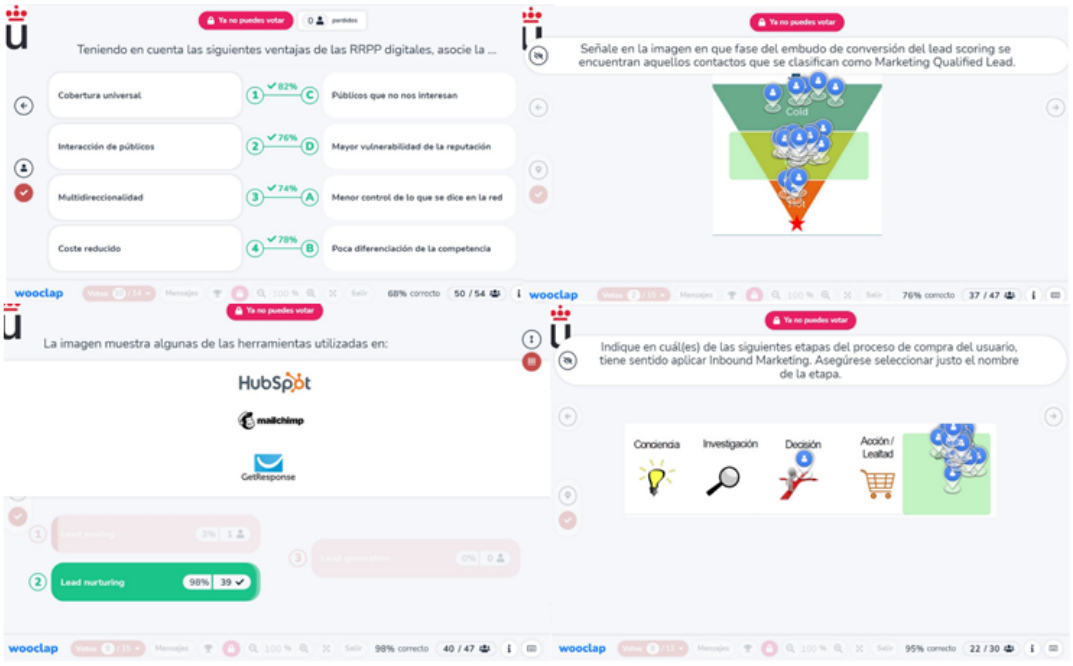

Figure 1. Example of SY activities in the OFCC and FFCC courses

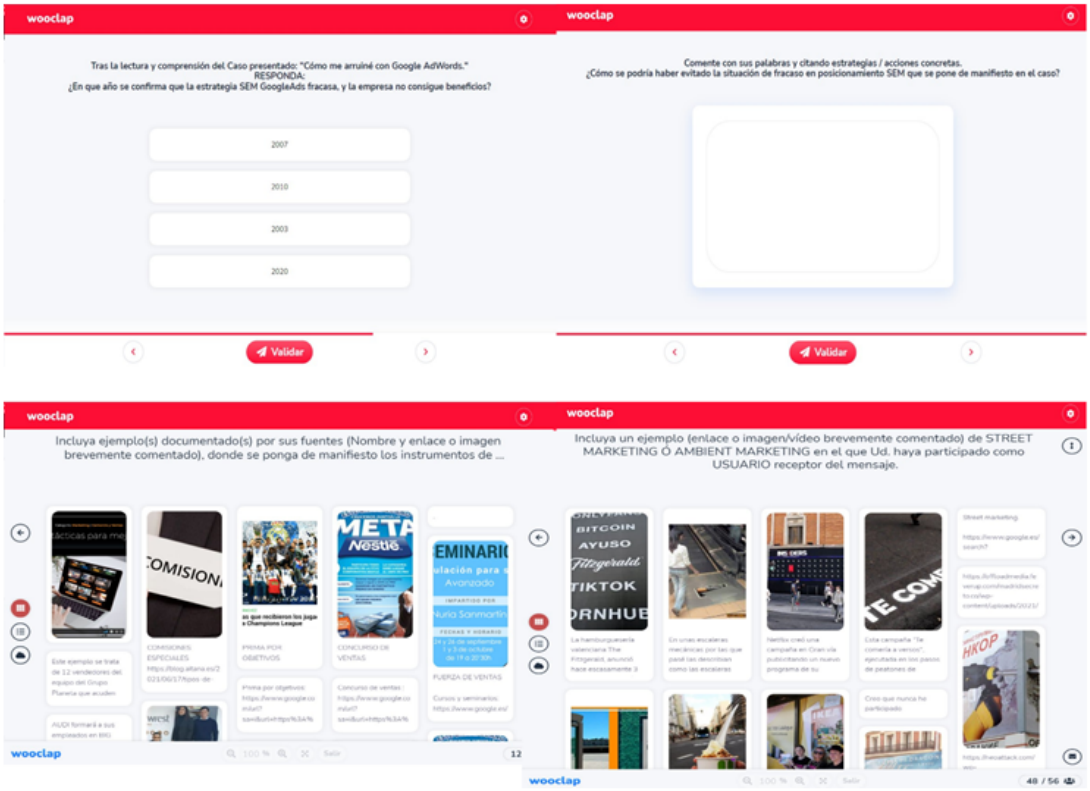

Figure 2. Example of AS activities in the OFCC and FFCC courses

The after-school activities were AS, as shown in Figure 2. These activities focused on individually reinforcing learning and collaboration and encouraging discussion and reflection. The students participated in a total of 39 assessment activities, 27 SY and 12 AS.

In the FFCC group, the application of the FL methodology was maintained, and the classes were adapted to a face-to-face modality. The resources, teaching materials and AS and SY activities created for the previous course served as a source for the redesign, updating and transformation of those used in the face-to-face modality. A total of 29 evaluation activities were performed: eight were AS, and 21 were SY. Figures 1 and 2 show examples of the activities developed.

The difference in the number of AS and SY activities performed in each course was determined by the adjustment of the course development in each group, the number of students and the modality in which the course was taught.

The CTFM exam was performed in a traditional synchronous face-to-face mode. However, in the extraordinary call of the CTFM and in all the calls of the OFCC and FFCC courses, exams were administered online, face-to-face and using university computer classrooms. In this case, exams were accessed digitally through the Moodle exam tool, with a question bank composed of more than 200 questions. These questions were configured as multiple choice, random and proportionally distributed answers by the type of content and the degree of difficulty.

In the OFCC and FFCC courses with FL methodology, the teacher conducted a survey of students at the end of the semester to learn first-hand about their perceptions of the FL methodology. The items on the questionnaire were extracted from various studies (Ruiz-Jiménez et al., 2022; Zhai, Gu, Liu, Liang & Tsai, 2017; Tsai et al., 2012). The five questions were measured on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) (Table 1). The questionnaire was conducted online and voluntarily in the last class session and took approximately 10 minutes to complete. The percentage of participation was 97% in the OFCC and 67% in the FFCC.

Survey on the perception of the FL methodology				
Assign a score from 1 to 5 (1 strongly disagree and 5 strongly agree) for the following statements:				
	No. Items	Groups		Source
The preparation and presentation materials of the FL classes allowed me to learn and study more efficiently.	1	OFCC	FFCC	Ruiz-Jiménez et al., (2022)
I receive learning support in FL classes for AS and SY activities.	1	OFCC	FFCC	Zhai et al., (2017)
My comprehension with the FL methodology improved with AS and SY activities.	1	OFCC	FFCC	Ruiz-Jiménez et al., (2022)
It took me a long time to adapt to the FL methodology.	1	OFCC	FFCC	Tsai et al., (2012)
I think that with FL, I will achieve better grades.	1	OFCC	FFCC	Ruiz-Jiménez et al., (2022)
Participants		61	44	
% Participation		0.97	0.67	

Table 1. Instrument used to measure students' perception of the FL methodology

Additionally, in the FFCC course, the questionnaire was expanded by incorporating two questions related to the degree of perceived effectiveness in the FL model and students' preferences between this model and the traditional model. The questionnaire items were selected from previous studies, where there was only one correct answer among three possible answers (Cavazos, 2018; Bishop & Verleger, 2013). Table 2 shows the information associated with this expanded survey. The questionnaire was conducted online and voluntarily, with an approximate duration of seven minutes. The percentage of participation was 64%.

Survey of preferences on the FL methodology			
Select one of the possible options:	No. Items	Groups	Source
Perception of the effectiveness of the FL model	1 of (3)	FFCC	Cavazos, (2018); Bishop and Verleger, (2013)
Learning model preference	1 of (3)	FFCC	
Participants		42	
% Participation		0.64	

Table 2. Instrument used to measure the effectiveness of and preference for the FL methodology

3.3. Methodology

To analyze the AP of the students in the three courses of study, the average grades of the SY and AS activities, the exam (EX) and the total grade (TG) for the subject, which have values from 0 to 10 points, were considered. Quantitative data were analyzed with SPSS 27.0 and G * Power 3.1.9.7.

The variables defined for the study were the average grade of the student for all AS and SY activities, grade obtained in the ordinary or extraordinary exam (EX), total grade obtained (TG) and the course indicator, modality, and teaching methodology (CTFM, OFCC, FFCC). The variables were over 10: AS, SY, EX and TG, except for the independent variable of course type, with values of 0 for CTFM, 1 for OFCC and 2 for FFCC.

To measure the differences in AP between the OFCC and FFCC courses with FL methodology in different modalities and the CTFM course with a traditional methodology and a face-to-face modality, we considered the type of course (CTFM, OFCC, FFCC) as the independent variable and as dependent variables (AS, SY, EX, TG). We used the Kruskal–Wallis statistical test for its validity in samples that do not follow a normal distribution, which was previously corroborated through graphic analysis and the Kolmogorov–Smirnov test.

Next, to determine the significant differences in the AS and SY between the courses with FL methodology and traditional methodology, post hoc analyses were carried out with the Games–Howell statistic, which helped us understand what previous researchers expected to learn about students' grades in the courses where the FL methodology was applied.

Considering the significant differences in performance on AS and SY activities among the study groups (CTFM, OFCC and FFCC) with different sample sizes, where n1 = 94, n2 = 63 and n3 = 66, an analysis was performed a priori and post hoc with the G * Power tool to identify the possible effect of these sampling divergences in the findings. For this purpose, the samples of the three groups were matched to the smallest size, corresponding to n = 63, and the same values of (1-β) and alpha of error probability obtained in the results of the study were maintained. The results of the analysis revealed a slight variation in the magnitude of the effect of the significant differences in grades on AS activities, from medium-large to large. However, this modification of matching the sample size does not impact the size of the effect of the significant differences of the SY activities because this effect size is maintained at the medium degree.

Before analyzing the positive influence of the AS and SY activities on the AP of the three courses, the existence of significant and positive associations was analyzed by calculating the Spearman correlations, including their degree and effect (Faul, Erdfelder, Lang & Buchner, 2007) between AS and SY and between AS and SY activities and the remaining variables (EX, TG).

Subsequently, the possible positive influence of AS and SY activities on student performance was analyzed. For this purpose, the binary logistic regression test was performed for each group of interest using the method of entry of successive steps backward because this study is exploratory. We proposed to explain whether students with higher grades on AS and SY activities had a greater chance of obtaining a higher AP in each course. The grades on SY and AS activities were considered predictive independent variables, and the variable (PASS_SUBJECT) that represents passing or not passing the subject was considered a dichotomous dependent variable. This variable was created by transforming the variable TG, corresponding to the total grade of the subject, and assigning a value of 0 for grades less than 5 points and a value of 1 for grades between 5 and 10 points.

To validate the model, the necessary checks were carried out, including the fulfillment of the necessary assumptions when considering more than one independent predictor variable. The Durbin-Watson statistic was considered, with values between 1 and 3 indicating that the residuals were independent, and the variance inflated factor (VIF), with necessary values close to 1 indicating the absence of multicollinearity.

Finally, based on the results of the questionnaires conducted in the OFCC and FFCC courses, a descriptive analysis was performed on two levels: the perception of FL and FL preferences.

4. Results

The results are presented in four sections: the first corresponds to the analysis of the differences of the AP between the courses with theFL methodology (OFCC and FFCC) and the course with the traditional methodology (CTFM) to contrast the study hypotheses H1 and H2. The second section considers H3 and therefore analyzes the associations of AS and SY between courses with different learning methodologies and modalities (CTFM, OFCC and FFCC). The third analyzes the positive influence of AS and SY on the AP in the three courses to consider hypothesis H4. Finally, the fourth section studies the perception and preferences of the FL model, with the objective of contrasting hypotheses H5 and H6.

4.1. Analysis of the differences in academic performance between courses with FL and traditional methodologies

To determine the existence of differences in the AP in the AS, SY, exam (EX) and total grade of the subject (TG) in each course (OFCC and FFCC) applying the FL methodology and the CTFM course applying the traditional methodology, we used the Kruskal–Wallis test. The CTFM, OFCC and FFCC methodologies were set as dependent variables, and AS, SY, EX, and TG were set as independent variables.

To calculate the size of the Kruskal–Wallis effect, the squared epsilon coefficient, E^2 R (Tomczak & Tomczak, 2014), was calculated; the interpretative norms were small (E2 R ≥0.01), medium (E^2 R ≥0.06) and large (E^2 R ≥0.14) (Faul et al., 2007). The results of the test (see Table 3) identified a medium-large effect of the course and the learning methodology on the AP for AS, H(2)= 27.406, p <.001; and a medium effect for SY, H(2)= 14.836, p <.001. The remaining EX and TG scores did not show significant differences, with a small effect size for EX and no effect for TG, which leads us to accept hypothesis H1, which proposes the existence of significant differences in AS and SY activities between courses adopting the OFCC and FFCC methodologies with courses adopting the CTFM methodology.

To detect significant differences in the AS and SY between the courses with FL methodology and the course with traditional methodology, post hoc analyses were performed based on the Games–Howell statistic. The results showed that in the flipped class taught online in the OFCC course, the grades on AS activities were higher (Mdn = 9.06) than in the CTFM course with the traditional classroom methodology (Mdn = 7.61; p =.011) CI 95% [0.22; 2.09]. In the FFCC course with the flipped class taught in person, AS activities also led to higher grades (Mdn = 9.03) than in the CTFM course with the traditional classroom methodology (Mdn = 7.61; p =.008) CI95% [0.25; 2.06]. Additionally, the scores of the SY activities were higher (Mdn = 10.0) in the FFCC course with the flipped class taught in person than those obtained in the CTFM course with the traditional in-person methodology (Mdn = 8.38; p. =.015),CI 95% [0.17; 2.00]. However, the scores on SY activities were lower (Mdn = 8.04) in the OFCC course with the flipped class taught online than those in the CTFM course with the traditional classroom methodology (Mdn = 8.38; p. =.015), CI 95% [0.17; 2.00]. These results support the H2a hypothesis, which proposes that grades on AS activities, for both the OFCC and the FFCC methodologies, are greater than for the CTFM methodology. However, in the case of SY, the H2b hypothesis is rejected because only in the FFCC methodology were the grades greater than in the CTFM methodology. The grades on SY activities in the OFCC methodology were lower than those in the CTFM methodology.

	CTFM (n=94)		**OFCC (n=63)**		**FFCC (n=66)**				
Variables	**Mdn**	**Range**	**Mdn**	**Range**	**Mdn**	**Range**	**H**	**p**	***E²R***
AS	**7.61**	**9.71**	**9.06**	**10.00**	**9.03**	**9.17**	**27.406**	**<.001**	**0.123**
SY	**8.38**	**10.00**	**8.04**	**9.60**	**10.00**	**10.00**	**14.836**	**<.001**	**0.067**
EX	7.70	6.16	7.03	6.02	7.46	6.33	5.298	.071	0.024
TG	7.70	8.13	7.81	5.65	7.91	8.04	1.292	.524	0.006

** Very significant probabilities. p = .001; * Significant probabilities. p <0.05;

E^2R (effect size): .01: small, .06: medium, .14: large; Mdn: Median

Table 3. Differences between grades by course and learning methodology

Additionally, this study focused on comparing the AP between the traditional methodology and reverse learning. It would be interesting to provide information about whether there are significant differences in the AS, SY, EX and TG scores between the face-to-face and online modalities, both with the FL methodology. For this purpose, the Mann−Whitney U test was conducted after previous confirmation by graphical analysis and the Kolmogorov−Smirnov test that these were two independent samples corresponding to OFCC and FFCC, both with a nonnormal distribution. The groups (OFCC and FFCC) and dependent variables (AS, SY, EX, TG) were considered independent variables. The results of this test allowed us to confirm the authors' suspicions about the nonexistence of significant differences in the AS, SY, EX and TG scores between the two groups with the FL methodology and different modalities (OFCC and FFCC). Nonsignificant differences were obtained in the AS, EX, and TG scores between these two groups with the same methodology and different modalities. Importantly, significant differences were found for the SY scores, although with an effect size value (*g Hedges*) of.03, where 10 = small, 30 = medium, and 50 = large (Hedges, 1981), indicating that the magnitude of the effect was less the smallest size. Therefore, we concluded that these differences in SY scores between the flipped class with face-to-face or online modality are negligible. In other words, we concluded that the modality used in the FL methodology did not lead to differences in the AS and SY scores.

Considering the results obtained and the different sample sizes of each study group (CTFM, OFCC and FFCC), where n1 = 94, n2 = 63 and n3 = 66, a priori and posthoc analysis were carried out. The G * Power tool was used to identify the possible effect of these sampling divergences. The same values of (1-β) and alpha of error probability obtained in the results of the study were considered to determine the impact on the size of the effect of the significant difference tests; if the sample sizes are equal, the groups smallest in size would correspond to n = 63. The results obtained by pairs of groups (CTFM and OFCC) and (CTFM and FFCC) reveal a slight variation in the magnitude of the effect of the significant differences in the AS activities, from medium-large to large. However, in SY activities, there is no impact on the size of the effect of the significant differences because this size is maintained at the medium degree.

4.2. Analysis of associations of asynchronous and synchronous activities between courses with different learning methodologies and modalities

After performing a correlation analysis between the scores that showed significant differences (AS, SY) among the three research groups (CTFM, OFCC and FFCC), significant and positive associations were detected, both between these scores and the remaining variables (EX, TG). These results are provided in Table 4 with the correlation coefficients, statistical significance (Sig.), effect size (p) and statistical power (1- β) of the Spearman correlation test.

	CTFM (n=94)		**OFCC (n=63)**		**FFCC (n=66)**	
	AS	**SY**	**AS**	**SY**	**AS**	**SY**
SY	**.694****		**.586****		**.674****	
Sig	**<.001**		**<.001**		**<.001**	
p	0.83		0.77		0.82	
1-β	1		.99		.99	
EX	**.608****	**.402****	**.405****	**.534****	**.483****	**.377****
Sig	**<.001**	**<.001**	**.001**	**<.001**	**<.001**	**.002**
p	0.78	0.63	0.64	0.73	0.69	0.61
1-β	1	.99	.99	.99	.99	.99
TG	**.671****	**.475****	**.687****	**.748****	**.765****	**.719****
Sig	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
p	0.82	0.69	0.83	0.86	0.87	0.85
1-β	1	.99	1	1	1	1

*Sig < .05, ** Sig. < .01,p=.10: low, p=.30: medium, p=.50: high

Table 4. Associations between grades by course and learning methodology

Importantly, the effect calculated for all the significant associations found was high. The strongest high-grade relationships were obtained in the OFCC and FFCC inverted class courses, between SY and AS activities with

the TG, as well as in the CTFM course, between AS and SY activities, with the TG and with EX. In addition, in the FFCC, the SY activities with the AS showed similar results. The least strong low-grade relationship was achieved between SY and EX in the FFCC. The remaining relationships found were moderate and were present in the three courses: between AS with SY and EX and between SY and EX in the OFCC, between AS and EX in the FFCCand between SY with EX and TG in the CTFM.

The above results support hypothesis H3, which proposes a significant and positive relationship between AS and SY grades and between these and the TG, with both the CTFM methodology and the OFCC and FFCC methodologies.

4.3. Analysis of the positive influence of asynchronous and synchronous activities on academic performance in the three courses

To find the possible predictive variables of student performance, considering the study sample, logistic regressions were performed in the objective courses. For this purpose, the differences, and significant associations between the grades by course, previously analyzed, were considered.

After performing additional calculations with the variables and the relationship between them, given all the estimated models adjusted to the available sample and the objectives of this research, it is possible to determine a model that explains the role of SY and AS activities on AP. For this purpose, the model shown in Figure 3 is proposed. First, a binary logistic regression model is conducted for each course (CTFM, OFCC, FFCC) with a backward method of entry of successive steps. An exploratory study is conducted to predict the effect of grades on the SY and AS activities, as independent predictor variables, on passing or not passing the subject (PASS_SUBJECT), as a dichotomous dependent variable. This variable is created by transforming the variable TG and takes a value of 0 for grades less than 5 points and a value of 1 for grades between 5 and 10 points.

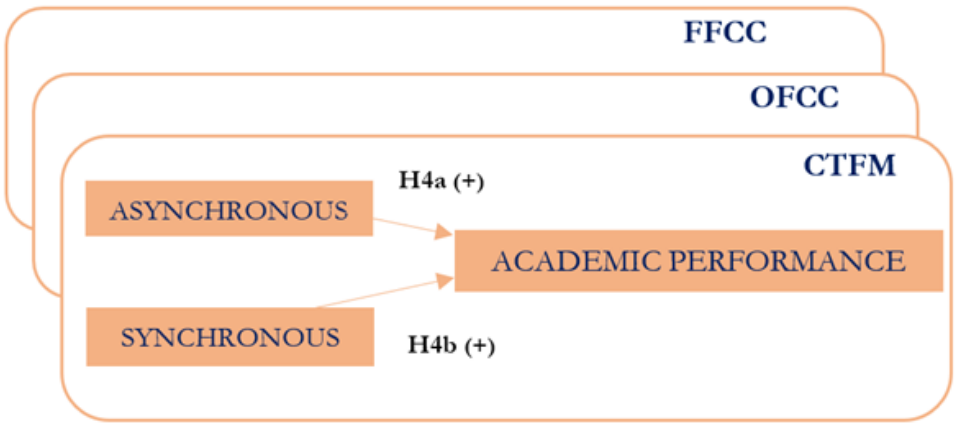

Figure 3. Effect model of AS and SY scores on AP

Among the purposes of the logistic model are to determine the presence or absence of a relationship between one or more independent or exogenous variables and the dependent or endogenous variable, to measure the magnitude of this relationship and to explain or predict the probability that the criterion variable is equal to 1 as a function of the values adopted by the predictor variables (Jovell, 1995).

Given the options chosen and the sample data, the values shown in Table 5 were obtained for the introduced independent variables. Analyzing the three models in step 2, the SY activities are eliminated because they have no explanatory effect for AP (passing the subject or not), given the grade on the AS activities.

Academic performance (*Does not pass vs. passes subject*)				CI95% for Odds Ratio	
	Steps	**B (ES)**	**Lower**	**Odds Ratio**	**Upper**
CTFM model	**Step 1**				
	AS	0.33(0.28)	0.80	1.40	2.44
	SY	0.34 (0.32)	0.76	1.40	2.60
	Intercept	-0.17(0.87)			
	Step 2				
	AS	0.59(0.21)**	1.21	1.81	2.71
	Intercept	-0.14(0.86)			
	R^2=0.12 (Coxy and Snell); 0.35 (Nagelkerke). Model X^2=11.79; p <.01				
OFCC model	**Step 1**				
	AS	0.65(0.45)	0.80	1.92	4.62
	SY	0.64(0.86)	0.36	1.90	10.17
	Intercept	-3.71(4.87)			
	Step 2				
	AS	0.92(0.44)*	1.06	2.51	5.94
	Intercept	-0.89(1.42)			
	R^2=0.16 (Coxy and Snell); 0.65 (Nagelkerke). Model X^2=11.02; p <.01				
FFCC model	**Step 1**				
	AS	0.95(0.33)**	1.36	2.58	4.89
	SY	-0.32(0.24)	0.45	0.73	1.17
	Intercept	-1.74(1.2)			
	Step 2				
	AS	0.65(0.2)**	1.29	1.92	2.84
	Intercept	-1.89(1.13)			
	R^2=0.21 (Coxy and Snell); 0.46 (Nagelkerke). Model X^2=15.67; p <.001				

* Sig. < .05, ** Sig. < .01, *** Sig. < .001

Table 5. Effect of AS and SY scores on AP

Block 1 of each logistic regression shows that probability of success in the result of the dependent variable PASS_SUBJECT when AS is knownis 95.7% for the CTFM, 96.8% for the OFCC and 91% for the FFCC (see Table 6).

	Observed	**Predicted**		**Percentage Correct**
		Fail	**Pass**	
CTFM model	Fail	**1**	4	20.0
	Pass	8	**89**	100.0
	Overall Percentage	11.1	95.7	**95.7**
OFCC model	Fail	**1**	1	50.0
	Pass	1	**60**	94.4
	Overall Percentage	50.0	98.4	**96.8**
FFCC model	Fail	**2**	4	33.3
	Pass	2	**58**	96.7
	Overall Percentage	50.0	93.5	**90.9**

Table 6. Number and percentage of cases correctly classified in the prediction of passing or not passing the subject

Notably, the proposed models explain 65% of the variance in the variable PASS_SUBJECT in the OFCC, 46% in the FFCC and 35% in the CTFM. Interpreting the value of the exp (β) of the odds ratio, in the OFCC model, students with the highest grade on AS activities are 2.51 times more likely to pass the subject, while those in the CTFM and FFCC are between 1.8 and 1.9 times more likely to pass.

Additionally, the value of the Wald statistic in the three models indicates that the independent variable AS significantly contributes to the prediction of the dependent variable PASS_SUBJECT, CTFM: Wald: 8.46, gl = 1, p <.01; OFCC: Wald: 4.38, gl = 1, p <.05; FFCC: Wald: 10.55, gl = 1, p <.01.

With respect to the global contrast for the three proposed models and as observed in Table 5, the results of the goodness of fit test indicate that the calculated models improve the prediction of PASS_SUBJECT in the three courses, with X^2 = 11.79, gl = 1, and p <.01 for the CTFM, X^2 = 11.02, gl = 1, and p <.01 for the OFCC and X^2 = 15.67, gl = 1, and p <.001 for the FFCC. These results lead us to reject the null hypothesis that all the coefficients of the variables included in the model are equal to zero. In turn, the results of the Hosmer–Lemeshow test for CTFM (X^2 = 6.23; gl = 8; p>.05), OFCC (X^2 = 0.19; gl = 8; p>.05), and FFCC (X^2 = 3.30; df = 6; p>.05) also do not support the null hypothesis that the proposed model can explain what is observed.

Importantly, the models presented above were considered valid after verifying the fulfillment of the necessary assumptions, where a value for the Durbin-Watson statistic between 1.2 and 2 was observed in the three models. Therefore, we concluded that the residuals are independent, fulfilling the assumption of independence of errors. The VIF indicates that the assumption of non-multicollinearity is also met, with values of 1.0, 1.4 and 1.7 for the three models per course.

All of the above lead us to accept hypothesis H4a, which proposes that AS activities have a significant and positive influence on AP regardless of the methodology and modality used. We must emphasize that in the case of SY activities, hypothesis H4b is rejected because its influence is not significant.

These estimates and interpretations should be considered with sufficient prudence, considering the empirical scenario in which the research was developed, and the methodology was implemented, which limits the generalizability of the findings.

However, based on the number of global successes of the model, which is one of the most important indicators of goodness of fit, we can argue that the estimated equation is reasonable for classifying and predicting the categories of the endogenous variable. Therefore, we conclude that if the three models were applied to the sample observations, a success rate greater than 90% would be obtained for all the courses, with a cutoff of 5 points out of 10 for the average grades on AS activities.

4.4. Analysis of the perception and preferences of the inverted class model (FL)

After analyzing the results of the perception surveys of the FL model in the OFCC and FFCC courses, a total of 61 and 44 responses were obtained in the group, where the ratings of all the questions were similar, with values close to and greater than 4 out of 5 (see Figure 4). In both courses, the preparation and presentation materials of the classes, as well as the support in learning and the improvement in understanding through SY and AS activities, were valued positively. In the OFCC, more than 80% rated this approach positively, and more than 70% rated it positively. With respect to the adaptation to the FL methodology, it cost 12% of the time in the OFCC, and only 5% had time in the FFCC. Finally, regarding the expectations of the results after applying the FL methodology, the OFCC students think that this methodology will be effective in 92% of the cases, whereas those in the FFCC are less optimistic, with 68% believing it will be effective. Therefore, we can accept hypothesis H5, which proposes that students' perception of the FL methodology in OFCC and FFCC courses is positive regardless of the online or face-to-face modality.

Figure 5 shows the results of the expanded survey on the FL methodology in the FFCC course. The results show that 74% of the students perceive greater effectiveness with the inverted class model than the traditional model, and 24% perceive the methodologies to have similar effectiveness. These results lead us to accept hypothesis H6b, which proposes that in-person FL is perceived as more effective than the traditional methodology.

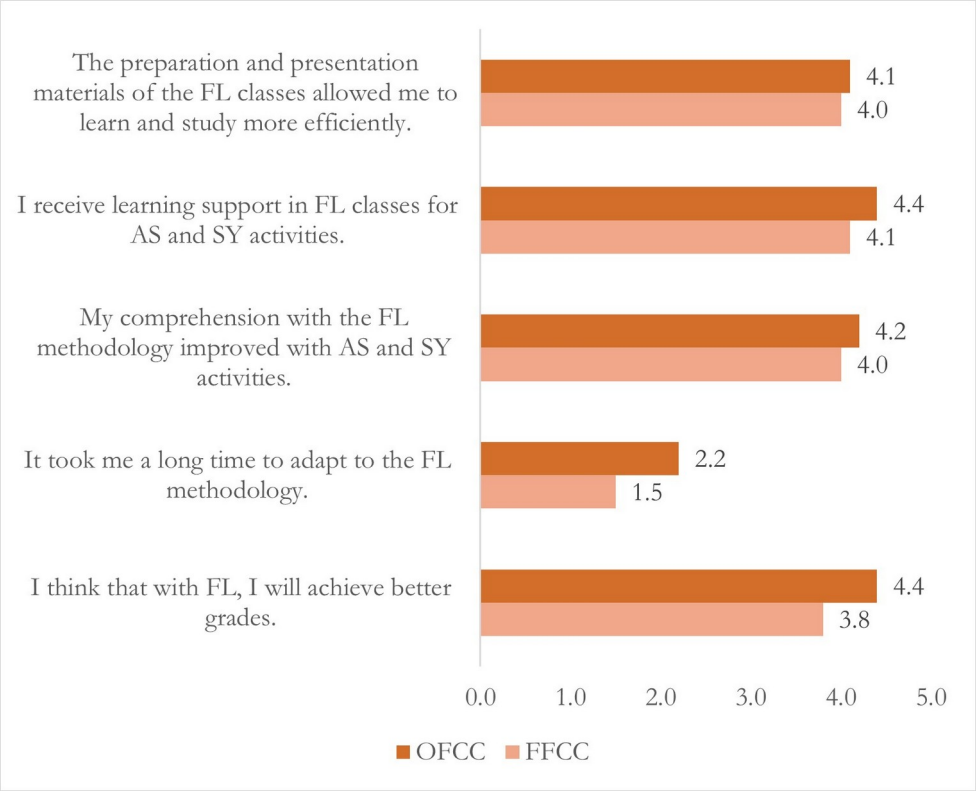

Figure 4. Results of the instrument used to measure the perception of the FL methodology

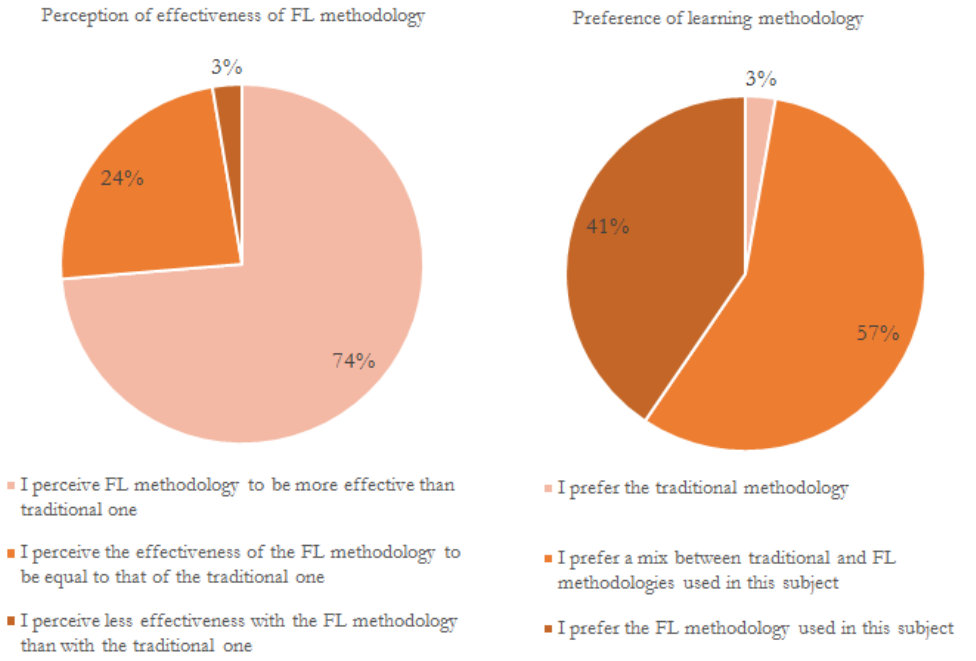

Figure 5. Results of the perceived effectiveness of FL and preference between the traditional methodology and FL, both in FFCC

Finally, given a choice between the face-to-face and traditional face-to-face FL models, 41% of students are inclined to choose face-to-face FL, while 57% prefer a mix of both inverted and traditional methodologies; therefore, we cannot accept hypothesis H6a, which predicts that students prefer face-to-face FL over the traditional face-to-face methodology.

5. Discussion and conclusions

The main objective of this article was to discover the role of AS and SY activities in the performance of university students. For this purpose, the academic results obtained and the involvement and motivation of students and teachers in the different learning methodologies are analyzed, and the effectiveness and perception of students regarding the FL methodology are compared to case of the traditional methodology. Among the variety of studies in the literature on the flipped classroom model in different disciplines, the results did not indicate significant differences in grades with respect to the traditional methodology (Davies, Dean & Ball, 2013; McLaughlin et al., 2013; Adnan, 2017). However, in some cases, the results show a considerable improvement with this methodology (Day & Foley, 2006; Schroeder, McGivney-Burelle & Xue, 2015; Albert & Betty, 2014).

This study addresses the importance of renewing knowledge and providing a greater understanding of the possible influence of the teaching methodology of the flipped class, taught in different modalities (online and face-to-face) and through different assessment activities (AS and SY) on students' performance, perception, and assessment. To this end, the research hypotheses were tested through different phases of analysis, and the results invite reflection.

First, the results reveal that students obtained better AP in AS activities when the FL methodology was applied in either of the two modalities (online and face-to-face). These results encourage us to consider the importance of creating interactive AS activities that are sufficiently attractive and motivating to prepare students for theoretical knowledge and to reinforce their learning after class, especially in an inverted classroom environment.

Similarly, better AP is achieved in SY activities when the FL methodology is implemented in person. However, very similar results are obtained in SY activities in the online FL modality and the traditional face-to-face methodology. These findings suggest that the SY activities conducted during the class session and in online mode may have a negative impact on the monitoring of activities and the achievement of satisfactory results. Among the factors causing this impact are students' attendance and follow-up in online sessions, the increase in difficulty for the teacher in tutoring, and the lack of support for personalized student learning. These courses also have groups that exceed 60 students, and classes are taught through synchronous digital means.

In the case of courses with the FL methodology, the best AP in the AS and SY activities was achieved with the face-to-face modality. This fact suggests that the face-to-face modality may eliminate the aforementioned difficulties of the online modality, hence being more effective in the teaching-learning process and in the achievement of results. Thus, following other authors, we consider that the teacher should be revalued as a mediator of learning (Gómez & Toala, 2017). This role change must lead to the use of constructive strategies that bring to fruition students' motivations (García & Balibrea, 2010; Ruiz, Graupera Sanz, Gutiérrez Sanmartín & Nishida, 2004) and that encourage interaction through cooperative learning (Díaz & Hernández, 2002). Therefore, this change implies that it is the teacher's responsibility to constantly research and redefine the teaching methodology. Thus, the focus is not only on what to teach but also on how to teach, thereby favoring students' process of acquiring knowledge.

The strongest positive associations with grade and high effect were found in the two courses with the FL model between AS and SY activities and the TG of the subject. Consequently, these findings indicate that FL may be effective in improving student grades. In addition, in all the teaching methodologies studied, the AS activities demonstrated greater predictive capacity of the AP with respect to passing the subject.

Of the three models obtained, the greatest predictive capacity and the best prognosis were obtained in the courses with FL, which showed greater impact on the online modality than in the classroom. This result causes us to reflect on the greater student dedication needed to carry out AS activities when students do not travel to classrooms. It is precisely in this methodology that these evaluative activities play an important role in the learning process because they are transformed into activities outside of class, conducted prior to class and to prepare the student in advance for the theoretical and practical parts of the course. Likewise, a percentage of these activities are completed after classes to reinforce learning. For this reason, they can be considered useful tools for learning in subjects that require a high degree of dedication, facilitating student understanding through

the repetition of content through videos, didactic material and multimedia activities of interaction and immediate feedback.

Regarding students' assessment of the FL model, in some cases, even with an increase in grades, students expressed negative comments about flipped learning (Ferreri & O'Connor, 2013), due to either the effort to complete work prior to the class (Strayer, 2012) or the increased responsibility from not receiving master classes (Wilson, 2013). Like other researchers, we believe that it is necessary for a process of adaptation to the methodology to take place, where students' negative attitude may improve as the course progresses (Mason, Shuman & Cook, 2013). However, in other areas, such as language learning, most students seemed to enjoy learning English with an FL modality and were more committed to the learning process (Lee & Wallace, 2018).

In our study, the assessment of students experiencing the FL model was very positive, regardless of the modality (online or face-to-face). Most students in both modalities expected to achieve good results and perceived these modalities as more effective than the traditional model. However, in the face-to-face modality, where the degree of preference for FL was also assessed, the majority chose the mixed methodology that combines FL and the traditional classroom, followed by the FL and finally the traditional classroom. These findings coincide with the results obtained in previous studies, such as the work of Albert and Betty (2014), who indicate the positive impact of the flipped class methodology on the grades of university students. These authors discovered that students who learned the subject through this method obtained higher grades than those who acquired knowledge in the traditional classroom, judging from the results of the three exams the students took. Likewise, the results of our study echo those obtained by Roach (2014), who showed a positive perception of students toward the learning acquired through the flipped class, finding that 78% suggested that more videos like face-to-face classes be used. This preference matches the results of this research, in which 74% of the students surveyed declared that they perceived greater effectiveness with the inverted class design than the traditional one and 57% affirmed their preference for a mix of the inverted and face-to-face methodologies. Roach (2014) also concluded that this methodology was useful in increasing student involvement but that a variety of activities were needed to maintain student motivation. Considering this finding, the present study aims to address this gap in research by providing evidence of not only students' higher grades and positive perceptions but also the influence of SY and AS activities on traditional and online students. The results revealed that the best AP was obtained by the students who took the course with the inverted class methodology (OFCC and FFCC) with AS activities, regardless of the modality (face-to-face or online). However, for SY activities, only students who took the course with the flipped and face-to-face (FFCC) methodology obtained better grades.

This FL model is closely related to the more autonomous learning process involving ICT resources. For this reason, the present research allowed us to improve and consolidate students' learning, AP and interest in participation outside and within classes. Additionally, the use of the FL methodology allowed the student to exercise more autonomy and better time management. The use of digital resources and study materials, made available in formats that support course content, facilitated later debate, and helped resolve doubts with the teacher and in the activities aimed at active and reflective learning.

We believe that these results, despite the specific and limited scope of the study, will be of great interest to the teaching community, contributing to improving learning strategies and teaching innovative methodologies. In addition, these novel teaching methodologies can improve student performance, which constitutes one of the main challenges in higher education.

Although the results provide evidence of the benefits of this study, we believe it is necessary to point out some limitations of the research. First, the subjects of this research were students belonging to a specific university degree program, which may not allow broad inferences regarding other university students or other populations. Second, the model proposed to explain AP only has one predictor variable. However, AP could also be attributed to the influence of other variables not considered in this study, such as other activities or the frequency of interaction, the time dedicated to study or the previous AP of the student. All these variables were examined in other studies.

In future research, it will be necessary to conduct a detailed study of each SY and AS activity implemented to evaluate the possible effects on learning and the consolidation of knowledge, motivation and the development of entrepreneurial skills demanded by the labor market.

The flipped learning model could be extended to other subjects, particularly subjects with a high theoretical load. In subjects that are more practical, a combination of methodologies would be more appropriate. In this manner, personalized tutoring could be achieved, especially in the development of projects and problem-solving skills.

To conclude, the present work highlights new implications for the use of active methodologies in teaching practice. Specifically, it confirms how the use of the inverted class method with the performance of SY and AS activities improves student performance and facilitates the acquisition of the contents of a subject through motivation, reflection and problem solving.

Declaration of Conflicting Interests

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