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DEVELOPMENT ARTICLE

Implementation of the flipped classroom and its longitudinal impact on improving academic performance

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Abstract
The objective has been to know the impact of the flipped classroom methodology on the academic performance of students during their training process in relation to the traditional methodology over time, in order to establish baselines in the academic grades in both models. The research is of a quasi-experimental type of non-equivalent groups, with a longitudinal trend design in the data collection process. The entire available population has been selected, with 1.236 students participating, exploring the grades as an analytical resource, from the 2010/2011 to the 2019/2020 academic years. The results show statistically significant differences in the improvement of academic performance with the flipped classroom methodology. Furthermore, the results reinforce that the flipped teaching model effectively promotes students' interest, their capacity for autonomous learning and personal and cooperative relationships.

Keywords Traditional learning · Blended learning · Flipped classroom · Academic performance · Cooperative/collaborative learning

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Introduction

Internet is favoring the emerging methodological change in education. One of the methodologies favored by the use of the Internet is the flipped classroom. Research has shown that there are advantages when comparing this methodology with the traditional one (Burnham & Mascenik, 2018; Busebaia & John, 2020; Decloedt et al., 2020; Fisher et al., 2017; Guy & Marquis, 2016; Karabulut et al., Karabulut, Cherrez, et al., 2018; Porcaro et al., 2016; Sahin et al., 2015; Thai et al., 2017).

However, it is not easy for teachers to plan virtual teaching (Ujiret al.,2020; Zawilinski et al., 2020), as they have to coordinate previous online work, immediate tasks in the face-to-face class, creation of audiovisual resources and continuous evaluation (Mojtahedi et al., 2020). To implement this methodology and make it effective, materials must be prepared and classes must be organized (Mason et al., 2013), and that requires extra time, additional effort (Green, 2015; Karlsson & Janson, 2015) and technological academic formation (Abad & González, 2019; González & Abad, 2020).

The expansion of technologies in higher education has meant the need to recognize their added value for quality teaching and active learning (Blau et al., 2020), so educators require expanding their digital competencies and strategies. The European Framework for Digital Competence of Teachers (DigCompEdu, 2017) shows these specific digital competencies for all educational stages. Its intention is to provide a general reference framework (governments, national and regional organizations, educational organizations, vocational training providers and educators) to develop models of digital competency.

After a decade of working with both methodologies, we noticed that students present lower-order cognitive skills, mainly emphasizing, in the words of the students, memorization (Mingorance, 2019; Torres et al., 2019). In the flipped classroom model, emphasis is placed on teaching students active learning, their participation and involvement is required to move from lower order thinking skills to the acquisition of higher order thinking skills (Bishop & Verleger, 2013; Erol, 2020; Tucker, 2014; Zou, 2020), leading to a benefit when they are asked to inquire, search for information, analyze a content and express their point of view (Mohamed & Lamia, 2020), favoring their critical thinking (Al-Samarraiel et al., 2019; Al-Zahrani, 2015), which fosters the development of their learning to learn competence (Cerea, 2019).

Other benefits are improving students' engagement (Cronhjort et al., 2017; Hutchings & Quinney, 2015; Hwang et al., 2015), their motivation towards the activities to be performed (Aydin, 2016; Chyr et al., 2017), linked to their responsibility, interest and commitment (Bouwmeester et al., 2019; Meyers, 2016), regulating their learning pace (Chyr et al., 2017; Tse et al., 2019) and improving the resolution of problems and situations posed during the teaching and learning process (Bognar et al., 2019; Long et al., 2016). The flipped classroom methodology increases student satisfaction (Lee et al., 2018; Muir & Geiger, 2015; Porcaro et al., 2016; Sahin et al., 2015; Troehling et al., 2017; Xiu et al., 2019), which has also influenced cooperative learning as knowledge enhancement (Chan, 2018; Fernandez et al., 2017; McNally et al., 2017), which includes explanation, sharing and effective acquisition of gained wisdom (Tran, 2014), as cooperative learning by applying flipped classroom methodology makes the student body accept more challenging tasks to develop more valuable and meaningful skills and experiences (Ahmad et al., 2019; Awidi & Paynter, 2019; Foldnes, 2016; Madjar et al., 2017; Tinungki, 2015), encourages interactions (McLean & Attardi, 2018; Sein et al.,

2017) and knowledge sharing to stimulate mutual learning (Huang et al., 2017; Foldnes, 2016; McCollum et al., 2017) and creativity (Huang, 2020).

Many recent studies have been conducted on the impact of flipped classrooms on student achievement in various areas and subjects (Ugwuanyi, 2022). This work highlights the favorable influence on academic performance, as an effective and active learning technique for learning and student interest, as well as for motivation and engagement, and improvement of critical thinking skills. The ability of teachers and the opportunity to have more time to work with students in the classroom is a substantial feature. Students can work together to solve problems, instead of than sitting home alone doing work they may not understand (Masadeh, 2021). Flipped classroom, teacher-student interaction, timely feedback, fulfillment of personal needs, infrastructural support, uninterrupted Internet access facility, and online communication mediated by technology increases students' satisfaction with online learning (Iqbal et al., 2022).

The consolidation of the flipped classroom methodology is accompanied by the presence of information and communication technologies (ICT), and that in education improves the acquisition of knowledge and skills (Maldonado et al., 2019; Mingorance et al., 2017). An important component of effective learning is student engagement (Weiser et al., 2018). Technological resources have seen increased participation in education (Cabero et al., 2019), contributing to the benefits of active methodologies, which influence personal interrelationships, leading to a connection between the flipped classroom methodology and ICT as a central element on which the transformation of university teaching pivots (Hasse, 2019; Henderson et al., 2018; Ishak et al., 2020).

The research consulted exposes significant differences of higher academic performance compared to traditional teaching, which is explained in student manifestations of better understanding of the subject matter, optimized learning and higher test scores (Burnham & Mascenik, 2018; Guy & Marquis, 2016; Fisher et al., 2017; Karabulut et al., Karabulut, Cherrez, et al., 2018; Porcaro et al., 2016; Sahin et al., 2015; Thai et al., 2017). Not all research demonstrates positive results when comparing both methodologies, nor does it demonstrate significant differences in student achievement (Blair et al., 2016; Ryan & Reid, 2016; Troehling et al., 2017). Several studies reveal the need for further research examining outcomes on student achievement through experimental and quasi-experimental designs with cross-sectional and longitudinality (Karabulut, Cherrez, et al., 2018; Karabulut, Jaramillo, et al., 2018; Stöhr & Adawi, 2018), as there is a great deal of indirect evidence on the topic of improved academic achievement and student satisfaction when flipped classroom is applied.

The present research demonstrates its importance in this subject, focusing on final performance in the subject. By measuring the evolution of performance over a decade, the longitudinal variable helps to study its association with the flipped classroom methodology (Busebaia & John, 2020; Strelan et al., 2020; Torres, 2019; Wong & Wong, 2019), evidencing its importance, since students can spend more time thinking, obtaining more detailed knowledge and producing superior results (Gómez et al., 2020). It is necessary to establish good working guidelines based on the formulation of activities as a high-level cognitive strategy by facilitating the integration of students' knowledge in the learning process (Hwang et al., 2020), increasing students' engagement by making them more responsible for their own learning and the time spent on tasks in the classroom (Rathner & Schier, 2019). Students draw on their prior experiences and knowledge, try to interact with the teacher and peers, and this exchange helps them to computer-assisted collaborative learning and actively construct knowledge (Han & Ellis, 2019), by inquiry and analysis of their learning. Also it impacts on students' motivation and improves their academic results.

The results obtained have their transfer to any branch of knowledge, whether Health Sciences, Social and Legal Sciences, Arts and Humanities and Engineering and Architecture, allowing university teachers in general to transform the teaching–learning process to encourage and involve students through an effective active approach. See for example Ruiz et al. (2020), where the flipped classroom method is introduced in the teaching of statistics through ICT, more specifically through AppES, a project whose objective is to develop different statistical topics by means of applications that allow providing didactic material for the student's self-learning and that serve for teaching use in the classroom.

The need for this study, and therefore, also its strength, is precisely its longitudinal nature, spanning a decade, as opposed to the cross-sectional studies reviewed. It is a significant aspect of the research field when technology and pedagogy is rapidly changing.

Materials and methods

Objectives

The purpose of the research focuses on the impact of the flipped classroom methodology on students' academic performance during their training process with respect to the traditional methodology over time, in order to establish baselines. We want to find out if the grades of university students who learn through a flipped classroom methodology are higher than those whose classes are taught with a traditional methodology, since grades are the result of learning caused by the didactic and methodological activity of the teacher and produced in the students (Affuso et al., 2022; Alarape et al., 2022; Yildirim & Gülbahar, 2022).

For this purpose, it was formulated the following research questions: What are the significant differences in the implementation of traditional and flipped classroom methodologies? Are there representative differences between the average grades of the groups that used traditional and flipped classroom methodologies? May the learning resources used by both methodologies be associated with performance? Are there significant differences in the level of withdrawal from the subject according to the methodology applied?

Design of the research

The present study has been developed from a quantitative methodological perspective, characterized as an empirical-analytical research of quasi-experimental non-equivalent groups, with a longitudinal design of tendency during the data gathering process (Walser, 2014), in relation to the efficacy of the methodological intervention (Price et al., 2015). Longitudinal studies entail an effective alternative to recognize the evolvement of an aspect, in this case methodological and performance, and can significantly contribute to know the conclusions arising (Cohen et al., 2011).

Participants

In the research a total of 1.236 university students, from the Faculty of Educational Sciences of the University of Granada (Spain) have participated, between the academic years 2010/2011 and 2019/2020, comprising 1159 women (93.8%) and 77 men (6.2%). In particular, all students enrolled in the subject "Didactics: theory and practice of teaching"

during a decade were chosen for the research. Working with all population makes our research is more accurate and rigorous from statistics viewpoint because we eliminate any potential bias through the sampling technique.

Classes during the first five years of this decade were given following a traditional methodology, with the participation of 554 students (522 females, 94,2%, and 32 males, 5,8%), while classes given during the following five years of the period under review were carried out applying a flipped classroom methodology, being 682 the number of students who participated (637 females, 93,4%, and 45 males, 6.6%), and using as resources more technological means, like a learning platform, multimedia contents, smartphones and social media, presentations, working guides and a class journal.

Description of the teaching: methodologies and resources

The study is focused in the methodological strategies implemented, the resources available, and how they have been used, during the decade from 2010 to 2020. The significance of carrying out this research on the basis of the knowledge from those ten years implies a value of the experience developed and the results obtained, being possible to prove that the reflections and conclusions originate from reality itself, providing us precise indications that can be applied to other realities.

The course is taught in the first semester of the first year of the Degree in Early Childhood Education, at the Faculty of Education Sciences of the University of Granada, Spain. It belongs to the field of basic training in education, with a teaching assignment of six university credits. Carried out in the morning hours in two weekly teaching sessions (one session of a theoretical nature -ordinary class- and another of a practical nature -seminar-) each with a duration of two hours, that is, four hours per week, from September until January.

Tables 1 and 2 describe the methodological process followed with traditional and flipped classroom teaching, respectively.

Note that Prado is a learning management system (LMS) based on Moodle, which the University of Granada uses to support face-to-face teaching and virtual teaching management.

Results

All results have been analyzed by means of the SPSS program, version 24 and R program, version 3.6.2 (IBM, 2016; R Core Team, 2019). Grades obtained from 1.236 students during the ordinary examination session over ten years were used, and has been noticed that 79 students did not attend the exam to obtain a final mark, consequently the latters were eliminated for the moment from the research and will be analyzed at the end, in order to verify if the method applied affects the "withdrawal from the subject".

Figure 1 appears the evolution of the average grades obtained, is exposed the initial hypothesis we contemplated in this research regarding the improvement of grades after applying the flipped classroom method. There is a decline of academic achievement in the course 2017/2018, precisely, the year where it was impossible to apply the flipped classroom method in all its totality, because there was not a fully equipped classroom with technological resources when applying the flipped classroom methodology. Therefore, a

Table 1 Methodological process with traditional teaching

Methodology	Resources	Proposal	Students
Traditional	Regular classroom Textbook PowerPoint and Prezi Work guides	No previous activities to be carried out at home were specified The teacher explained the relevant content in class The teacher highlighted the most relevant ideas The explanations were supported by slides (PowerPoint, Prezi) that were projected at the same time, providing summaries, diagrams, concept maps, tables and/or images	The students took notes on what they thought was necessary, or made notes in the margins of the textbook
		Implementation	
		After the theoretical explanation, a work guide was provided to be filled individually (some guides were solved in pairs or even quartets), which was done during the last thirty minutes of class, approximately, in handwritten form and handed in In the following classroom sessions, there was a sharing in the first minutes to discuss the tasks done and clarify any doubts that might arise The content was concluded and we continued with the new one	

Table 2 Methodological process with flipped classroom

Methodology	Resources	Proposal	Students
Flipped classroom	Technology classroom WhatsApp Prado platform, University of Granada Kahoot Virtual work guides	A technology classroom was made available for classroom sessions, with a computer for each student	Before attending the class, the students addressed the corresponding theory at home with one week in advance In the previous class, through the Prado platform and also by WhatsApp, students were informed about the basic content to be tackled They downloaded from Prado the corresponding digital file with the work guide to be done during the previous week The tasks were to go deeper into the topic: research, entrepreneurship and audiovisual creation. With virtual links or links to multimedia content: own videos and Internet access Most of the work was autonomous
		Implementation Once the previous work had been done during the corresponding week, the file with the answers of the work guide had to be uploaded to Prado Already in the technology classroom, in a face-to-face manner, three moments were essentially distinguished to proceed: - A brief sharing to situate the topic and resolve possible doubts - Carrying out new virtual activities to apply theory to reality: making infographics, creating blogs, editing videos or creating portfolios. Even gamification with Kahoot - In the last ten or fifteen minutes of the session, another brief sharing was done, as a summary, to remember what had been worked on And at the end of the session, the next content to be developed was explained	

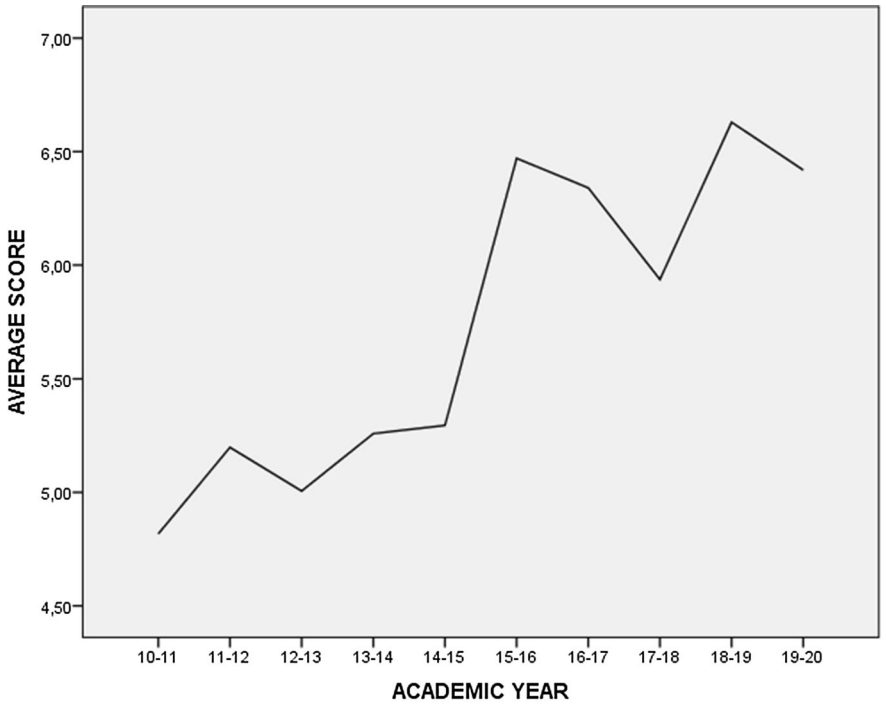

Fig. 1 Development of the average grade obtained through the last registered ten years

mixed methodology was carried out what it could explain this decrease in the scores of the students.

The improvement of the flipped classroom methodology with respect to the traditional one is observed. Previously to the analysis of the significance of differences when applying both methods, the descriptive analysis is completed showing the usual descriptive measures, as well as the percentage of failing grades (F), passing grades (D, C), notable grades (B) and distinction grades (A) with each method and depending on the academic year.

Table 3 is an indication of the efficacy of applying the flipped classroom methodology. With regard to the mean, grades of students have improved almost 1, 3 points, reducing

Table 3 Descriptive summary of grades in connection with the methodologies

Descriptive measures	Methodology	
	Traditional	Flipped classroom
N	522	635
Mean	5.16	6.34
Variance	1.217	2.134
%Failed (0–4.99]	28.0	20.2
%Passed [5–6.99]	66.1	40.5
%Notable [7–8.99]	5.9	39.2
%Distinction [9–10]	0	.2

approximately by 8 per cent the number of failing grades. The great improvement happens in the percentage of notable grades, as it went from almost 6 per cent of the students with this mark in the traditional methodology to almost 40 per cent in the flipped classroom system. This is reflected too in Table 4, where the research is divided by years. We must stress that, based on the results obtained, the benefit of applying the flipped classroom methodology seems to be reflected especially among the students that pass, but not so much among the students that fail, as, except during academic years 2010/2011 and 2012/2013, where there was a high number of failing grades, this performance data during courses 2011/2012, 2013/2014 and 2014/2015 do not excessively differ from those academic years during which the flipped classroom methodology was applied, albeit a slight drop of failing grades can be appreciated.

With the purpose of testing if the differences aforementioned between the application of one methodology or the other can be considered significant, the Wilcoxon test for independent samples is used. This test is also known as Wilcoxon–Mann–Whitney test and it is applied instead of the famous t-test when independent are not normally distributed (Fay & Proschan, 2010). Previously it was checked through the Shapiro-Wilks test that grades obtained during the flipped classroom method and traditional class did not follow normal distribution ($p < .001$ in both cases). Others tests available in the literature in order to study the normality assumption are, for instance, Kolmogorov–Smirnov test, D'Agostino test or Anderson—Darling test (Yap & Sim, 2011). All of them were also applied, being the result significative ($p < .001$) just like Shapiro-Wilks test.

In Table 5 results applying the Wilcoxon test are demonstrated. Considering the usual level of significance $\alpha = .05$ and due to the fact that $p < \alpha$ (Cohen et al., 2011), there are significant evidences in data to conclude average grades differ depending on the method applied, being greater in the flipped classroom methodology. This conclusion is made by means of the values of the average range. The Wilcoxon test uses the range of the data instead of the own data. Range of a data is the order number, or position, which this data takes up according to the total set of the data ordered from least to greatest. Logically, the sample, whose average range is greater, will have values bigger and, therefore, its average will be bigger than the other sample. Furthermore, with the purpose of measuring the magnitude of the effect because the value alone is not enough (Fritz et al., 2012; Sharpe,

Table 4 Descriptive summary of grades during each course

Descriptive measures	Academic year									
	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20
N	58	174	85	102	103	37	141	154	143	160
Mean	4.82	5.20	5.01	5.26	5.30	6.47	6.34	5.94	6.63	6.42
Variance	.952	1.271	1.328	1.496	.835	1.920	2.388	2.664	1.722	1.627
%Failed (0–4.99]	56.9	21.8	42.3	19.6	18.4	10.8	19.9	30.5	14.0	18.1
%Passed [5–6.99]	37.9	72.5	50.6	72.5	77.7	48.6	39.7	37.7	36.4	45.6
%Notable [7–8.99]	5.2	5.7	7.1	7.9	3.9	40.6	39.7	31.8	49.6	36.3
%Distinction [9–10]	0	0	0	0	0	0	.7	0	0	0

Table 5 Results of the Wilcoxon test to study the effect between applying traditional methodology and flipped classroom methodology

Methodology	N	Average range	*p*	*r* Effect size: statistics and confidence interval at 95%
Traditional	522	404.27	< .001	.473; [.423–.526]
Flipped classroom	635	722.63		

2013; Tomczak & Tomczak, 2014), we estimate r effect size and its confidence interval calculated at 95% confidence. Thus, these results indicate us that the difference produced between applying one methodology or another is important and consequently, it should be kept into account.

In order to verify to what extent the applied methodology is related to the grade obtained by the student body, we take the grades groups Fail [0, 5), Pass [5, 7), Notable [7, 9) and Distinction [9, 10]. As we are talking about two qualitative dichotomous variables, the Fisher exact test is used to study if there is a association. Also relative risks and odds-ratio are kept in mind in order to establish relations among variables (Agresti, 2002).

According to the results that are represented in Table 6, it is possible to conclude the following:

- The probability of failing the subject is 1.538 greater when the student body has been given class using the traditional method. The fraction of failed students opposing those that managed to pass the subject is 1.388 times larger when they carried out their classes applying the traditional methodology.
- The probability of obtaining a grade between 5 and 7 is three times greater among the student body that participated in the traditional methodology. The fraction of students that obtained a grade between 5 and 7 against those who got another different mark, is 1.633 times larger amongst students given class with a traditional methodology.
- The probability of achieving a notable grade (7 to 8.9, a B) is 10.2 (1/.098=10.2) times higher amongst the student body involved in the flipped classroom method. The fraction of students that got a notable grade versus those who received a mark different is 6.62 times higher in those cases where students applied the flipped classroom methodology.

Table 6 Tables 2 × 2, p value associated to the Fisher exact test and value of relative risks and odds-ratio for each considered group of grades

	Grades							
	Fail (F)		Pass (D, C)		Notable (B)		Distinction (A)	
	Yes	No	Yes	No	Yes	No	Yes	No
Traditional class	146	376	345	177	31	491	0	0
Flipped classroom	128	507	257	378	249	386	1	1
p	.002		< .001		< .001		.999	
Odds-ratio	1.538		2.867		.098		–	
Relative risk	1.388		1.633		.151		–	

- There is no relation between getting a distinction mark or not depending on the teaching method applied. That is because the *p* value is higher than the usual level of significance.

Once proven the great positive influence that the flipped classroom methodology has on the marks of the student body, the research focuses on assessing if the type of resources deployed during this methodology also have an impact on grades, and if with the passage of time a gain on them has happened, thus contemplating if has refined teaching from previous years regarding the adaptation of the flipped classroom methodology to the class. During the academic course 2015/2016, the first year the flipped classroom methodology was introduced, the university platform SWAD and the virtual application Prezi were used as teaching means, whereas in the subsequent years the university platform PRADO, virtual applications Kahoot and Prezi were used, and audiovisual/multimedia resources as well. In order to study this effect, first of all a nonparametric analysis of variance (ANOVA) about this lustrum was carried out. ANOVA is an extension of the t-test when there are more than two groups, that is, in this case, the results in the five academic years where the flipped classroom was applied (Scheffe, 1999).

In particular, the Kruskal Wallis test was used, which turned out significant ($p < .002$). Consequently, one can assume that the average mark obtained throughout the five academic years during which the subject was studied using the flipped classroom was different. To discover in what years it was different, two-to-two Post-Hoc tests were carried out through the Wilcoxon Independent Samples Test and applying the Bonferroni correction for adjusting the significance level (Armstrong, 2014; Hollander & Wolfe, 1973; Kruskal & Wallis, 1952) (Table 7).

Regarding the data obtained, it is possible to conclude that the resources employed do not affect the average grades obtained by the student body, nor it is observed a significant gain from one year to the next, except the year 2017/2018 to 2018/2019, when only occasionally a technological resources classroom was available to carry out the flipped classroom methodology, whereas during the rest of years that same classroom was used regularly, which reinforces the connection between the usual use of technological resources and the flipped classroom methodology. Besides, given that there are not significant differences among the academic courses, except for the year where a mixed methodology was carried out, on the one hand, these results fortify the validity of the design faced with various threat to internal validity such as the university has better enrolment year-by-year resulting in better learning outcomes. On the other hand, these outcomes also corroborate the credibility of findings, as one could think it would be

Table 7 P values associated to the two-to-two Post-Hoc tests through the Wilcoxon Independent Samples Test with the Bonferroni correction

Academic Year	Academic year				
	15–16	16–17	17–18	18–19	19–20
15–16	–	–	–	–	–
16–17	.999	–	–	–	–
17–18	.999	.6596	–	–	–
18–19	.999	.5756	.0004	–	–
19–20	.999	.999	.3786	.1824	–

interesting to switch back to traditional class after a few years of flipped classroom to see if there is a decline of academic achievement.

Finally all students registered in the database are reconsidered (students that did not attend the exam are included again), and it is studied if the number of students that withdraw or drop ut the subject is influenced by the teaching method applied. Following the disposition contemplated in Table 4, it is obtained that the teaching method has no effect on the decision of the student body to attend or not the exam in order to pass ($p = .483$ Fisher exact test).

Discussion

In this research the impact of both models on academic performance over time is known. The results show that students performed better with the flipped classroom method, as reflected in the Wilcoxon independent samples test and the associated effect size.

We found that there are statistically significant differences between the two methods. The data are consistent with other recent research, a meta-analysis on the effects of the flipped classroom method on student achievement in various educational areas and levels relative to the traditional model (Strelan et al., 2020), an improvement in student achievement is evidenced for the same reason (Busebaia & John, 2020), the flipped classroom method causes a significant effect on the performance and effectiveness of students in the acquisition of skills compared to classes taught with the traditional method (Decloedt et al., 2020), in the optimization of learning, obtaining higher grades in exams (Burnham & Mascenik, 2018; Guy & Marquis, 2016; Fisher et al., 2017; Karabulutet al., Karabulut, Cherrez, et al., 2018; Porcaroet al., 2016; Sahin et al., 2015; Thai et al., 2017) or that the results demonstrate statistically significant differences between students who followed both methodologies (Mingorance et al., 2019).

Regarding teaching activity and involvement, highlight four aspects: number of teaching hours, teaching preparation, student consultations and assignment evaluation (Mojtahedi et al., 2020; Ujir et al., 2020), and add the student ratio. It involves more effort and time investment (Green, 2015; Karlsson & Janson, 2015; Zawilinski et al., 2020). The implementation of the flipped classroom model involves the prior development of virtual resources and the selection of the appropriate digital media for students to access the content (Mason et al., 2013), it is a challenge to advance in active methodologies and acquire multimedia technological competencies to be effective.

Research also shows the importance of students' previous work before going to class to help students understand basic knowledge (Zou, 2020). This methodological change produces new ways of learning to learn among students and improvements in their critical and creative thinking (Al-Samarraiel et al., 2019), and fosters a positive attitude of students towards learning (Lee et al., 2018; Muir & Geiger, 2015; Porcaro et al., 2016; Sahin et al., 2015; Troehling et al., 2017; Xiu et al., 2019). It involves greater involvement and autonomous work, which coincides with other studies in focusing the interest of the teaching and learning process on the learner (Chan, 2018; Fernández et al., 2017; McNally et al., 2017) and its significant correlation with academic performance (Ahmad et al., 2019; Awidi & Paynter, 2019; Foldnes, 2016; Madjar et al., 2017; Tinungki, 2015), as it is precisely an important factor that tells us whether there is effectiveness and efficiency (Tran, 2014).

The application of the flipped classroom model as an active methodology, together with technological resources, concludes that students improve their participation during classes

(Chyr et al., 2017; Guy & Marquis, 2016), as well as the interaction among them, which favors communication processes (McLean & Attardi, 2018; Sein et al., 2017), socialization of those involved in the process (Huang et al., 2017; McLean & Attardi, 2018) and cooperative learning (Foldnes, 2016). By coming to class with prior knowledge, makes it possible for students to participate more and interact with the teacher and their classmates because they know the content to be worked on, establishing cooperative learning and sometimes peer instruction. All this can be seen in the face-to-face classes and in the virtuality of the platform's chats.

The results also reveal that the use of technological resources has been a significant factor in improving student achievement. The connection between the use of technological resources and student academic performance, and their effective influence on active learning is confirmed (Cabero et al., 2019).

All this leads us to consider the effectiveness and efficiency of our work. Effectiveness is established in the relationship between the employed resources, in the process of methodological intervention, and the achievements obtained with them. Efficiency is translated as the level of achievement of the proposed objectives, being in our case the improvement of performance through grades (general criterion in universities) with a new methodology, in line with the research made by Honebein and Reigeluth (2021).

Conclusions

The flipped classroom methodology has emerged as the main active teaching alternative to replace the traditional teaching method. The results of the present research reflect statistically significant differences in the grades obtained by the students, being higher, which shows that the application of the flipped classroom methodology is more effective in achieving an improvement in the performance of students with this prolonged experience in time.

We have observed that in active learning, by inquiry, students use more technological resources inside and outside the classroom. Students use the available devices and contribute to autonomy and personal work in the educational process (time, space, direction and pace), involving them with greater presence in the analysis of learning and the acquisition of their own knowledge. ICT is an excellent resource for educational innovation and student-centered learning, technological diversity is part of the active methodology of the flipped classroom, and involves students using their own devices and expanding their digital skills. We can affirm that the flipped classroom focuses on the design and use of virtual resources to help students adapt their learning, achieve greater transfer, propose more realistic activities and encourage more collaborative learning, that is, computer-assisted collaborative learning.

The flipped classroom methodology leads to the effective development of students' competencies through learning by doing, which also leads to an increase in their deep understanding of the subject matter and meaningful learning is achieved. This leads students to the acquisition of higher order thinking skills, which enables a person to achieve rational and reflective thinking, also innovative, critical and creative. Higher order thinking skills have been enhanced by the students' experimentation (know, know how to do, know how to be and be), for deepening learning as opposed to superficial learning, due to their greater active involvement in the achievement of the learning purposes, which has produced an improvement in performance.

The learning culture has been changed with the protagonist of the students, flexible learning environments have been used to establish more practical learning strategies.

Another factor that has increased the performance of students through the flipped classroom methodology is to know the person better, not only the academic aspect, but also the nature of each one.

Limitations and proposals for improvement

But not everything has been favorable. Some limitations can be identified: resistance to change, technological aspects and teaching perspectives.

When starting the application of the flipped classroom in students accustomed to the traditional methodology, the limitation of resistance to change is observed, since with the flipped classroom methodology there is more work to do and their responsibility is greater. A process of progressive familiarization and successive adaptation takes place, which can last the first month of the course, and students check by their own conviction the progress in improving their critical and creative thinking. It is also very useful to invite a student from the previous course to explain the experience to the students of the new course.

Not all students have basic skills in the use of technological resources, so the period of adaptation to change also serves to reconcile their technological training. And not all students have the same resources, so it is necessary to adapt the previous teaching work to the available resources.

It also implies an additional teaching effort in the preparation of classes, the work time is greater than the assigned teaching hours, the sequencing of activities and adaptation to the teaching and learning process, the virtual consultations of students, the evaluation of more activities and the ratio of students to be attended.

Considering the activities carried out outside the classroom and subsequently implemented in the classroom, it shows that the flipped classroom methodology is an active learning style, which includes technological and digital means to enhance learning. This also leads to an improvement in digital competencies, as demonstrated in the European Framework for Digital Competence and the European Framework for Educators' Digital Competence.

This research provides clear evidence of the advantages of implementing the flipped classroom method in the university setting, which invites further research and analysis to propose improvements in other teaching contexts, in the development of cognitive and reflective skills, innovation and creativity, in proposals for assessment models, in terms of teaching interdisciplinary, in association with gamification, in the application of simulators and augmented reality, or in the application with social media, among others, thus supporting the flipped classroom methodology for its continuous improvement, prevalence, usefulness and effectiveness in the face of the diversity of teachings, which will result directly in the improvement of student training, and consequently in social and professional improvement.

Suggestions for further research

Below, different proposals for future researches derived from the current investigation are introduced.

- Broaden the study variables that delve into academic, social and psycho-emotional constructs.
- Expand demographics nationally in other regions and universities, as well as internationally with other countries, whether on the same or different continents.
- Work with groups of different sizes and compare the results obtained with the flipped classroom methodology.
- Propose the development of this methodology to other disciplines and areas of knowledge.
- Introduce technological and pedagogical resources during the class to better monitor learning through interactive feedback controls.
- Establish qualitative and/or mixed methods to complement this methodology in future work.

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Declarations

Conflict of interest The authors declare that he has no conflict of interest.

Research involving human participants and/or animals For this type of study formal consent is not required.

Informed consent This is a theoretical study.

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