Macrothink Institute™

International Journal of Education
ISSN 1948-5476
2022, Vol. 14, No. 3

Flipped Classroom and Peer Learning: A New Approach to the Educational Process at University

George S. Androulakis[1,*], Dimitra Ap. Georgiou[2] & Maria Kaisari[1]

[1]Department of Business Administration, University of Patras, Greece

[2]Department of Educational Sciences and Social Work, University of Patras, Greece

*Corresponding author: Department of Business Administration, University of Patras, Greece. E-mail: gandroul@upatras.gr

Received: July 18, 2022 Accepted: August 15, 2022 Published: September 22, 2022

doi:10.5296/ije.v14i3.20090 URL: https://doi.org/10.5296/ije.v14i2.20090

Abstract

In this paper, a new flipped classroom model at the university emerged. The innovation of the model lies in the combination of two methods of the students' learning process: students work together in small groups before the class (cooperative learning) and also conduct presentations in groups within the class (group peer tutoring). Indeed, during the semester students alternate in the roles of the tutor and the tutee in the classroom process. The teaching experiment was carried out at the Department of Business Administration of the University of Patras in the context of the Calculus course of the 1st semester. Of the 344 participating students, 179 chose to follow the procedure of the flipped classroom while 165 the traditional lecture. It was revealed that the proposed model of the flipped classroom induces the students' academic performance of the students. In addition, this level of academic performance is maintained even after the semester in mathematics and in courses in different cognitive subjects. The proposed flipped classroom model that emerged, can offer benefits to the educational process and the students in terms of both traditional and distance learning environments.

Keywords: higher education, flipped classroom, group peer tutoring, cooperative learning, student performance

1. Introduction

The flipped classroom methodology is essentially the result of an innovative solution at the heart of student-centered learning (Jenny Moffett and Mill 2014; Morton and Colbert‐Getz 2017; Moravec et al. 2010; Prober and Khan 2013).

The "Flipped classroom" otherwise known as the "inverted classroom" (Sahin, Cavlazoglu, and Zeytuncu 2015) and as a form of inverted learning is characterized by the traditional lecture to be accomplished before the class while the work is completed inside the classroom (Fung, Besser, and Poon, 2021; Bergmann and Sams, 2012; Pierce and Fox, 2012; Roehl, Reddy, and Shannon, 2013; Lage, Platt, and Treglia, 2000). That is, a pedagogy in terms of which the lecture material is given to students before class, while classroom time is dedicated to discussion, problem-solving, assessment, individual learning, and presentation (Samaila, Masood, and Chau, 2021; O'Flaherty and Phillips, 2015). Further, according to the definition by Ojalvo and Doyne (2011) the student's engagement with the content occurs inside the classroom through the development of skills and practices, under the teacher's guidance and in collaboration with fellow students (Ojalvo and Doyne, 2011; Blair, Maharaj, and Primus, 2016).

Inverted learning has been applied for some years in higher education' diverse cognitive subjects (Brame 2013). Specifically for mathematics, inverted learning is one alternative to in-classroom learning and teaching (Network 2014; Nouri 2016; Setyawan and Rohmah, 2021; Van Alten et al., 2019).

Meanwhile, a big challenge for universities is the transition period from secondary education to tertiary education (Artigue, 2001; Wood, 2001; Wingate, 2007; McGhie, 2017; Postareff et al., 2017). Especially for first-year students, this transition is determined by certain factors able to affect students' decision to leave or persist in their studies (Androulakis et al., 2021). Especially in mathematics, the difficulties in transition are identified through "upper secondary school mathematics" and "advanced mathematics" as belonging to different institutional practices (Kaisari and Patronis, 2010).

Speaking about the transition period, a major concern of this work was that first-year students during quarantine could not visit the university classrooms and meet their peers and therefore additional obstacles emerged in terms of the transition to higher education. Therefore, peer group learning in the context of the flipped classroom is important to stand out towards the enhancement of learning through student intercourse. As far as cooperative learning is concerned, the emphasis is given to the learning autonomy of students before class while the case of peer group tutoring focuses on students' teamwork in terms of in-classroom activities.

At the same time, it could not be ruled out that the influence of the flipped classroom on students' learning outputs is an issue that has come under discussion. In fact, the inconsistency of the use of activities within the classroom consists one of the principal reasons for difficulties in regard to the conduction of comparisons (Fung, Besser, and Poon 2021).

2. Theoretical Background

The main focus of the flipped classroom is to shift what students have traditionally done in and outside of the classroom, such as presenting information and transmitting it through teaching (Låg and Sæle, 2019).

According to Zhao, He, & Su (2021) the adequate application of inverted learning that has the potential to offer students education harmonized with the "knowledge-based society" presupposes the removal from traditional educational frameworks towards innovative pedagogical approaches that incorporate a learning environment assisted by communication technology and information (Zhao, He, and Su, 2021). Indeed, the flipped classroom pedagogy expresses the central concept of innovative pedagogy (Baker, 2000). Students in terms of the latter are responsible for communicating their meanings through social interplay (Baker, 2000; Farren, 2016; Zhao, He, and Su, 2021).

Actually, peer tutoring is usually supported by the reason of "learning through teaching." This view extends to the old adage "to teach is to learn twice," requiring the revision of existing knowledge and skills (Topping 1996). The lesson from fellow students is characterized by taking on a concrete role: at any time during the process, one performs the role of teacher while the others display the role of tutees. Teaching by fellow students usually has a high focus on the content of the curriculum. The projects usually describe very specific interaction processes in which the persons involved are likely to have specific or general training or both of them. Further, their interaction can be guided by the supply of structured material, where there may be a degree of student preference (Topping 1996).

Focusing on the subject of mathematics, the traditional teaching does not seem to be the identical pedagogical approach (Harel and Trgalová 1996; Skovsmose 1994). Some reasons for this are that students in mathematics lectures may not pay the appropriate attention to the professor's explanations because they are concentrated on copying definitions, theorems from the table (Freitag, 2020; Feudel and Fehlinger, 2021), which leads to difficulty in processing information and understanding the content during the lecture (Fukawa-Connelly, Weber, and Mejía-Ramos, 2017; Lew et al., 2016). Therefore, in the discipline of mathematics (Fung, Besser, and Poon, 2021), it is important in terms of the effectiveness of the flipped classroom, one material before the class -pre-class material-, the repetition in the classroom -revision inside the classroom-, and the interaction' activities such as teacher's feedback, discussion, and cooperative work by fellow students (Fung, Besser, and Poon, 2021). However, the approaches of the flipped classroom present a structural diversity as the latter is related to the activities that precede the class and those taking place within it (Hurtubise et al., 2015; Jennifer Moffett, 2015; O'Flaherty and Phillips, 2015; Sharma et al., 2015; Morton and Colbert-Getz, 2017).

Although the idea of reverse learning is gaining popularity (Love et al., 2014; Tang et al., 2020), the effect of the flipped classroom is still ambiguous and its elements that could encourage the student's academic performance and perceptions are still weak (Bernard, 2015; Bishop and Verleger, 2013; Chua and Lateef, 2014; Giannakos, Krogstie, and Chrisochoides, 2014; Lelean and Edwards, 2020; O'Flaherty and Phillips, 2015; Ward, Knowlton, and Laney,

2018; Zainuddin and Halili, 2016; Zuber, 2016), mainly due to the inconsistency of theoretical frameworks, methods and activities within the classroom (Lin and Hwang, 2019; Lo and Hew, 2017; Zuber, 2016; Fung, Besser, and Poon, 2021).

Regarding academic performance, based on the central concepts and principles that characterize active learning, the flipped classroom compared to the traditional teaching should result in the advancement of students' academic performance (Morton and Colbert-Getz, 2017; Tune, Sturek, and Basile, 2013; Jensen, Kummer, and Godoy, 2015). The studies that confirm this hypothesis are not numerous (Morton and Colbert-Getz, 2017; Michael, 2006; O'Flaherty and Phillips, 2015; Stockwell et al., 2015; Street et al., 2015). In the same line of argument, according to (Blair, Maharaj, and Primus, 2016), existing research has focused little on the correlation of the flipped classroom with the student's results in the exams, that is on whether the above pedagogical methodology contributes to the encouragement of such learning outcomes. On the contrary, the majority of studies investigate the effect of the flipped classroom on students' experience (Blair, Maharaj, and Primus, 2016), and students' perceptions (Blair, Maharaj, and Primus, 2016; Bishop and Verleger, 2013).

Based on the above, a basis is formed for further research of the flipped classroom's correlation with students' academic performance.

Therefore, in the present research, a flipped classroom model is proposed and applied to encompass as its main features "group peer tutoring" within the university classroom and "cooperative-learning" outside and before it. The aim was to examine the effect of the proposed flipped classroom model on students' academic performance via the interpersonal interaction and cooperation developed.

Therefore, the following research questions are illustrated:

1) How is the performance of students configured in the final exams of the flipped classroom compared to the traditional?
2) What is the development of students' academic performance within the semester, in terms of the proposed flipped classroom model?
3) What is the development of students' academic performance in the subject of mathematics, up to one academic year later, in terms of the flipped classroom?
4) What is the development of students' academic performance in other subjects of the curriculum, up to one academic year later, in terms of the flipped classroom?

3. The Proposed Model: Theoretical and Methodological Perspectives

3.1 The Model

In the proposed model named Peer Learning Flipped Classroom (PL-FC) three objectives are combined: cooperative learning, group peer tutoring and flipped classroom. Groups of students shared experiences of cooperative learning participating in two contexts usually

separated: in-class and out-class learning environments.

3.2 Theoretical Perspectives of PL-FC Model

Cooperative learning has been at the center of educational research during the last decades (Slavin 1980; Roger and Johnson 1994; Felder and Brent, 2001; Herrmann, 2013; Littman-Ovadia and Freidlin, 2022). Typology and different models of application have been analyzed in detail from elementary to tertiary education (Johnson and Johnson, 2002; Kagan and Kagan 1994). Specifically, in the model proposed in the present research, cooperative learning is approached in a similar way as Kaufman et al. (1997) (Kaufman, Sutow, and Dunn, 1997) of which three applications in higher education are presented. The first application concerns cooperative learning outside and before the university classroom with small groups of students followed by group tutoring with a large audience in the university classroom. Furthermore, peer tutoring is a teaching method that has been analyzed theoretically and applied in various contexts widely (Moust and Schmidt, 1994; De Backer, Van Keer, and Valcke, 2015). Indeed, based on the typology introduced by Topping (1996) and the approach of Fineman (1981), (Fineman, 1981; Topping, 1996), in the present research the method of same-year group tutoring is applied, where a group of students participates in rotational presentations undertaken by a subgroup of them.

Both cooperative learning and peer tutoring are the basic components of peer learning (PL). According to Topping (2005) peer learning "involves people from similar social groupings who are not professional teachers helping each other to learn and learning themselves by so doing" (Topping, 2005, 631). Moreover, in the proposed model peer learning is considered independent of students' ability level and therefore all students who participated were offered the same opportunities for learning (Hew et al., 2021).

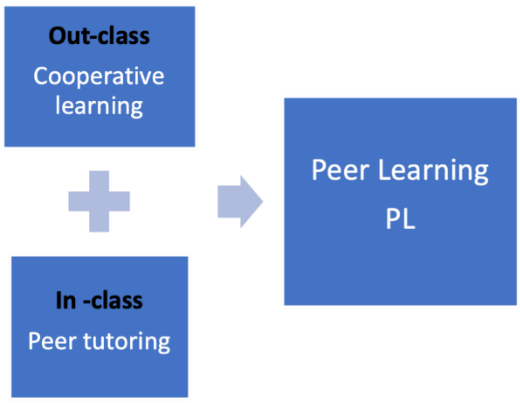

Figure 1. Basic Components of Peer Learning

Peer learning and flipped classroom are combined in in-class activities (Danker, 2015). In the present research, peer learning is also proposed in out-class activities illustrated in Figure 1. This perspective has not been investigated as long as it has come to our notice. According to Zheng & Zhang, (2020) "Since students in the flipped-classroom environment are required to

learn on their own before coming to class, peer learning could potentially help them decrease their learning anxiety, increase their learning engagement, and/or improve their understanding of the learning materials" (Zheng and Zhang, 2020, 5).

In the present research, subgroups of students formed tutoring groups composing the same in-classroom group. By rotation, tutoring groups implemented flipped classroom involving a specific subject. In this procedure, students change their roles during in-classroom activities from tutees to tutors. On total, students' out-class activities are based on peer learning (Boud, 1999; Topping, 2005; De Backer, Van Keer, and Valcke, 2015) and in-classroom activities stand on the basis of group peer tutoring (Topping, 1996). Therefore, the novelty in the proposed methodological context lies in cooperative learning outside and before the classroom and simultaneously in group peer tutoring inside the classroom. These approaches are combined to form the PL-FC model of flipped classroom as illustrated in Figure 2.

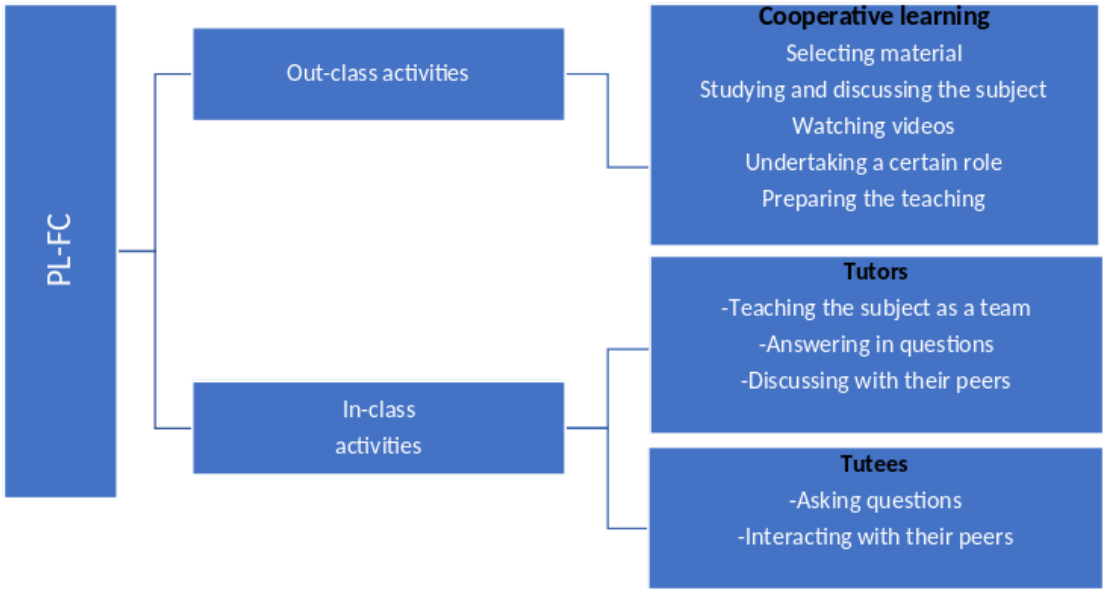

Figure 2. The PL.FC Model

3.3 Methodological Perspectives

3.3.1 Participants and Process

The teaching experiment took place in the context of the compulsory course "Calculus" in the winter semester of, 2020 in 344 first-year students at the Department of Business Administration of the University of Patras. The duration of the application was six months. It is noted that "Calculus" is an introductory course to students' mathematical thinking and simultaneously transitional from secondary to tertiary education. Its content had been formed to create links between Elementary and Advanced Mathematics. Furthermore, because it is taught in Business School it is enriched with problems in the context of micro and macroeconomic theory. At the beginning of the semester, students were informed about the

procedure and invited to participate. Two groups were created: the group of 179 students who followed the PL-FC model and the rest 165 who chose the "traditional" teaching.

The context of the teaching experiment took was a large lecture course. Towards the application of the PL-FC model procedure, illustrated in Figure 3, the course was redesigned into small groups as suggested by Ferreri and O'Connor, (Ferreri and O'Connor, 2013). In this respect, students were divided into groups, and each week in each tutoring group 3-4 students (tutors) undertook to teach a specific section of the course, creating original educational material shown on rotational presentations. By this procedure, students in the same group had to change their roles from tutors to tutees. Moreover, the supervision of the process in each group was assigned to Ph.D. candidates.

Students, at the beginning and at the end of the academic semester, had to solve a problem consisting of open questions in order to investigate possible changes in the issue of the resolution process. Specifically, these problems indicated abilities such as algebraic techniques, formulation of mathematical and economical contexts, construction and interpretation of diagrams and interpretation of economical concepts in the context of the problem.

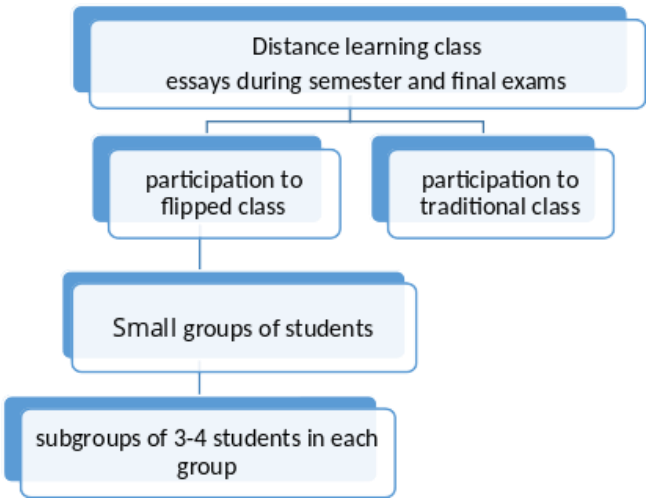

Figure 3. The PL.FC Model Procedure

Microsoft Teams (MS Teams) was used as the main tool of the educational process (Martin and Tapp, 2019). Lectures, tutoring, and flipped class were implemented via this tool. Each tutoring group created its own MS Teams channel, where a fixed day and time for teaching was set every week for each. All students regardless of their participation in the flipped classroom took part in written essays during the semester and also in the final exams. These written essays were given to students one week after the flipped classroom and the traditional lecture completion on each section taught.

3.3.2 Outside the Classroom

Each week, the group of tutors had to prepare the educational material for their teaching and post it in the online classroom. They could communicate with each other either via MS Teams or any other digital media they preferred. During their meetings, they watched videos, shared material, and discussed the topic of the teaching. They also divided the subject they had to teach into sections and each of them undertook one. Several tutoring groups assigned roles to their members such as the coordinator, the presenter, and the moderator of the final presentation. They also held a final meeting in which they rehearsed their teaching material and corrected possible mistakes. In terms of students' perceptions on the experience of the out-class activities, indicatively a student denoted: "*We could not choose a more appropriate method to achieve our goals than the collaborative method. It promotes cooperation and constructive dialogue while providing us with the opportunity to engage in discussions, to ask questions, and, above all, to work collectively, combining our knowledge. We divided the parts, gathered the best possible information from a wider variety of sources, and each worked with his/her part of teaching, exchanged views, asked questions, and came up with the final teaching together.*"

3.3.3 Inside the Classroom

During the teaching procedure, both the tutees and the supervisor had the opportunity to ask questions to the tutors. The tutors in turn answered questions and, in several cases, reconstructed or corrected some of their arguments. Therefore, an environment of discussion and interaction was created that is essential (Cobb et al., 1997; Alrø and Skovsmose, 2004) to the learning process.

Tutors also had the opportunity to communicate via MS Teams with their team supervisor, either in writing (chat) or via scheduled video conference, to answer their questions and give them instructions for their teaching. In the educational process described, supervisors, supported and guided students during their preparation, organized and coordinated the meetings and solved problems that arose during the semester. Finally, supervisors at the end of the semester evaluated each student on a 5-scale rating system; 20% was for the quality of educational material that tutors used inside the classroom, 50% for the knowledge of the subject and 20% assigned for the preparation and interest as perceived by supervisors during students' tutoring. Moreover, 10% was for the level of interaction between tutors and tutees.

4. The Proposed Model: Theoretical and Methodological Perspectives

Data processing was done with R software (R Core Team, 2022). The readr and readxl libraries (Wickham, Hester, and Bryan, 2022; Wickham and Bryan, 2022), were used to read the data, the summarytools, psych, kableExtra, apaTables and papaja libraries for statistical analysis (Comtois, 2021; Revelle, 2022; Zhu, 2021; Stanley, 2021; Aust and Barth, 2022) and for the graphical representations the libraries ggplot2 and ggpubr (Wickham et al., 2021; Kassambara, 2020; Wickham, 2016) were used.

Table 1. Performance of Students by Category and Type of Examination

Type of Examination	n	Mean	Flipped mean			Percentage of students per performance				
			Yes	No	Pvalue	Poor	Below Average	Average	Above Average	Excellent
Final Exams										
Final Exams	344	4.84	5.32	4.32	**	25.29	20.35	16.86	18.60	18.90
Problem solving at the beginning and end of the semester										
FinalExplenatory	282	4.96	5.29	4.47	**	6.32	54.65	12.27	16.73	10.04
ExplenatoryBegin	217	4.91	5.07	4.48		21.66	20.28	23.50	18.89	15.67
Results of midterm exams in theory										
Part_I_Tehory	253	4.90	5.05	4.58		26.48	8.30	25.69	19.76	19.76
Part_II_Theory	244	4.54	4.70	4.17		0.00	45.90	24.18	13.93	15.98
Part_III_Theory	236	4.57	4.66	4.37		0.00	63.98	15.68	1.27	19.07
Part_IV_Theory	223	4.54	4.64	4.27		0.00	56.50	19.28	0.90	23.32
Part_V_Theory	195	4.63	5.00	3.43	***	30.77	26.15	15.38	2.05	25.64
Results of midterm exams in exercises										
Part_I_Exer_1	252	4.71	4.75	4.64		23.81	0.00	51.19	7.54	17.46
Part_I_Exer_2	245	5.12	5.59	4.09	***	30.61	2.86	26.53	0.00	40.00
Part_I_Exer_3	253	5.54	5.72	5.14		22.92	0.00	0.00	77.08	0.00
Part_I_Exer_4	254	5.52	6.13	4.24	***	23.62	0.00	0.00	76.38	0.00
Part_II_Exer_1	249	4.60	4.71	4.36		26.10	38.55	10.04	1.20	24.10
Part_II_Exer_2	252	4.52	4.57	4.41		0.00	63.49	11.90	0.79	23.81
Part_III_Exer_1	241	4.71	5.11	3.85	**	20.75	38.59	1.66	28.63	10.37
Part_III_Exer_2	239	4.58	4.88	3.91	**	0.00	67.78	7.11	1.67	23.43
Part_IV_Exer	225	4.67	4.76	4.43		0.00	52.00	23.11	8.89	16.00
Part_V_Exer	204	4.58	4.64	4.38		0.00	58.82	13.73	0.98	26.47

Table 1 presents the averages of students' performance by category and type of examination. The columns capture the following:

• **Column 1** represents the type of examination,

• **n** presents the total number of students participating in each examination category,

• **mean** is the average grade of all students,

• **Yes** expresses the average grade of students who participated in the flipped classroom, and

• **No** the average grade of students who did not participate,

• **Pvalue** "***" denotes statistical significance less than 0.001, "**" statistical significance between 0.001 and 0.01, and "." statistical significance between 0.05 and 0.10 for the difference between "Yes" and "No" columns,

• **Poor**, **Below.Average**, **Average**, **Above.Average**, **Excellent** denotes the percentages of students per their performance in each examination type.

From Table 1 it can be observed that in all student evaluations, the students who participated in the flipped classroom have shown a higher-grade average than the performance of these students who did not participate in it.

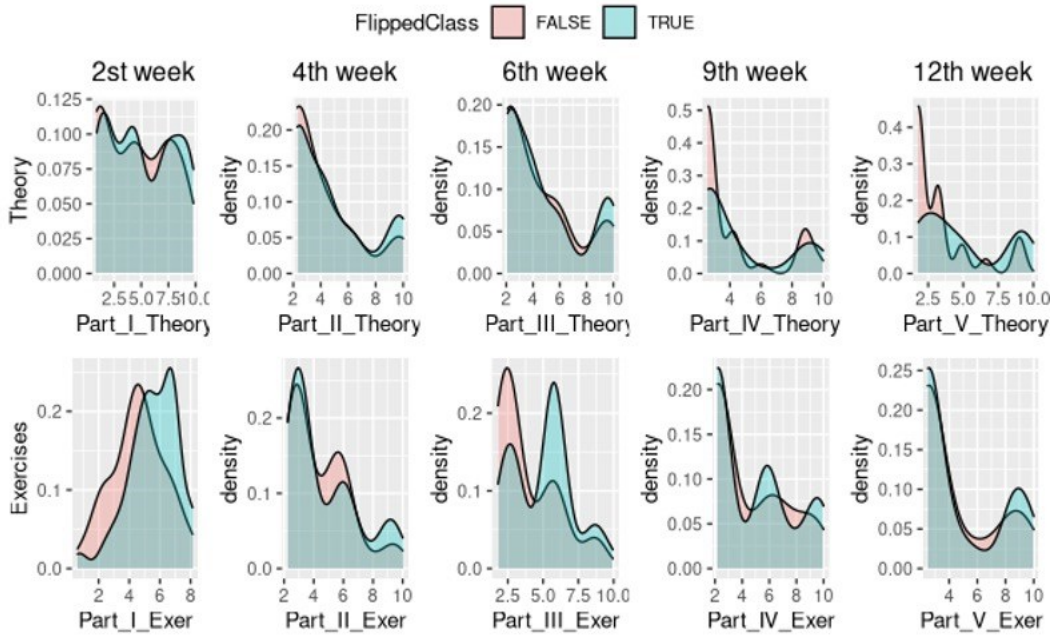

Figure 4. Performance of Students in the Intermediate Examination Tests in Theory and Exercises during the Semester

Figure 4 illustrates the performance of students in the intermediate writing essays (examination tests) divided into theory and exercises. It is noted that the intermediate tests were performed in the 2nd, 4th, 6th, 9th, and 12th academic week of the semester.

From the first row of subfigures of Figure 4 concerning the performance of students in theory it emerged that students who participated in the flipped classroom (cyan region) compared to those who did not participate (pink region) had: - better performance up to the 4th week, - stabilization -still having a slightly better performance than students who did not participate in the flipped classroom- from the 6th to 9th week, and - clearly better performance in the 12th week.

Focusing on the second row of Figure 4, in regard to the exercises, it is noticed better performance in all weeks, more intense though in the 2nd and 6th academic week for students who participated in the flipped classroom.

Students' overall performance in theory and exercises during the semester is illustrated in Figure 5. In Figure 5 it can be observed that the overall performance of the students who participated in the flipped classroom is better throughout the semester, having a progressively increasing performance over the academic weeks. Slight stabilization occurs in the 9th week and secondarily in the 4th week, which both encompassed the most difficult sections of the material that is Chapter 8 and Chapters 4-5. In contrast, in Chapters 6, 7 and 9, the difference in the performance of students who participated in the flipped classroom was intensively better than those who did not participate.

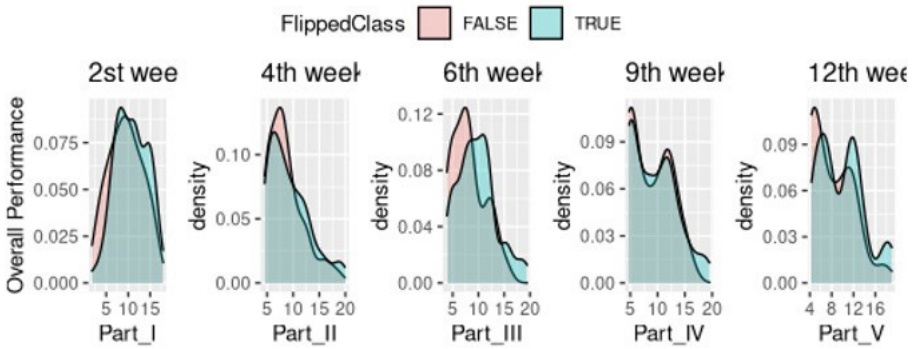

Figure 5. Student overall Performance in the Intermediate Examination Tests during the Semester

Focusing on the final exams see Table 1 it can be observed that the average grade in regard to students' performance who taught in the flipped classroom is 5.32 compared to the average of 4.32 represented by those students who did not participate in the flipped classroom. From ANOVA Table 2 it appears that there is a statistically significant difference in the average grade of students in the final exams intensively interrelated with the existence or not of their participation in the flipped classroom ($F(1,342) = 10.13$, $p=0.002$, $\eta_G^2=0.029$, 90% CI [0.007, 0.064]).

Table 2. ANOVA Table of Students' Performance in the Final Exams with Interpretive Variable Their Participation in the Flipped Classroom

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
FlippedClass	1	86.88	86.88	10.13	0.0016
Residuals	342	2934.11	8.58		

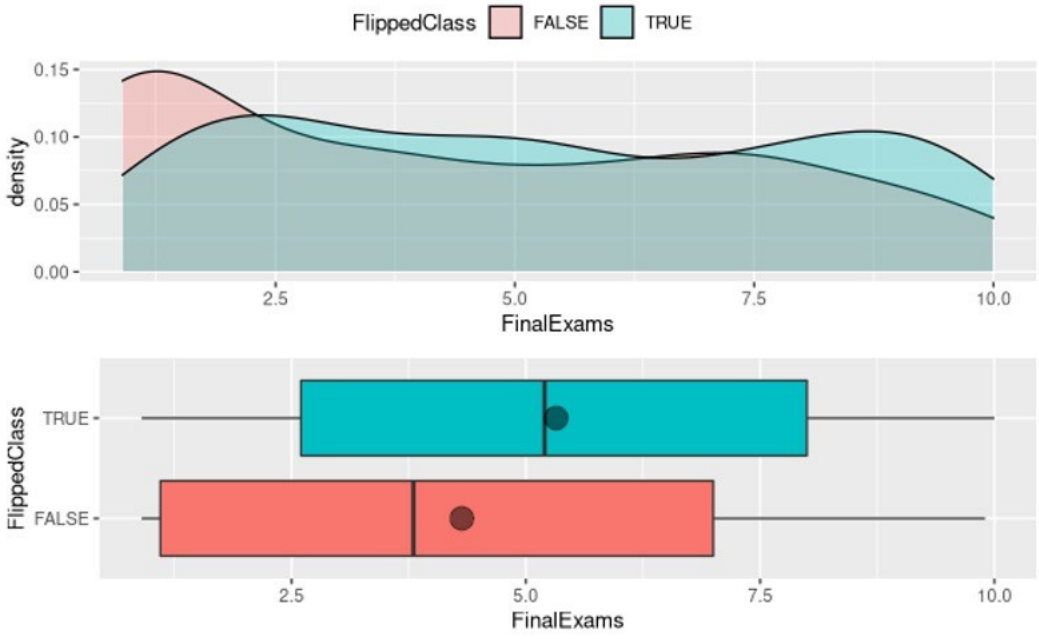

Figure 6. Boxplot and Density Plot of the Final Exam Grade in Calculus

In Figure 6 are illustrated the density plot and the boxplot representing the grades of students in the final examination who participated in the flipped classroom and those who did not participate. It is noticed that are similar, showing a positive shift for students who participated in the flipped classroom. The same conclusion is reached by looking at the result of the linear regression for the final examination grade in relation to students' participation in the flipped classroom, see Table 3 where the measurable difference is 1.01 units in the final examination (b=1.01, 95% CI [0.38, 1.63], t(342)=3.18, p=0.002). The pink area represents the performance regarding the final examination grade of students who did not participate in the flipped classroom. It is double-edged where the highest peak appears in very low performance (below 2) while the second peak shows up in higher performance (around 7). In contrast, the performance of students who participated in the flipped classroom is shifted to the right, where the two peaks are about the same height. This positive shift of the curve is interpreted as an overall boost in the performance of those students who participated in the flipped classroom, while the similar height between the two cyan peaks reinforces the assumption that for certain students this boost was more pronounced.

Table 3. Linear Regression of Students' Performance in the Final Exams with Interpretive Variable Their Participation in the Flipped Classroom

	Estimate	Std. Error	T value	Pr(>|t|)
(Intercept)	4.3170	0.2280	18.93	0.0000
FlippedClassTRUE	1.0059	0.3161	3.18	0.0016

In order to investigate if the good performance of the students in the role of the tutor (variable Edugrade.scaled) -as evaluated by the supervisors-, leads to a good performance in their final exams, a linear regression was performed, illustrated in Table 4. This was in regard to the grade in the final exams using as an interpretive variable the overall performance on the concrete evaluation criteria -described in the methodology subsection "Inside the classroom"- for students' role as tutors. Therefore, it was found that the performance of students as tutors has a statistically significant positive correlation with their performance in the final exams, increasing by 0.19 points each final grade for each unit grade as tutors. In addition, considering that the intercept is 4.3, it is noticed that the students who participated in flipped classroom even with a medium performance as tutors, had a higher-than-average score in the final exams.

Table 4. Linear Regression of the Exam Grade in Terms of Performance as an Instructor

	Estimate	Std. Error	T value	Pr(>|t|)
(Intercept)	4.3026	0.4799	8.97	0.0000
FlippedClassTRUE	0.1910	0.0806	2.37	0.0188

In order to determine whether the effect on students' performance who participated in the flipped classroom of Calculus is more permanent over time, the performance of the same students was examined as follows:

• **same semester**: in a course of the same (1st) semester named Financial Accounting I (BA107),

• **six months later**: in three courses in the 2nd semester, named Dynamic Mathematical Models (DMY.FinalExams), Financial Accounting II (BA108), and Money & Capital Markets (BA157),

• **one year later**: in two courses of the 3rd semester, that is Statistical Data Analysis (SAD.FinalExams), and Accounting Statement Analysis (BA119).

Table 5. Students' Performance from the Beginning of the Semester up to One Year later

	n	Mean	Flipped mean			Percentage of students per performance				
Type of Examination			Yes	No	Pvalue	Poor	Below Average	Average	Above Average	Excellent
Start of semester										
Part_I_Tehory	253	4.90	5.05	4.58		26.48	8.30	25.69	19.76	19.76
Part_I_Exer_1	252	4.71	4.75	4.64		23.81	0.00	51.19	7.54	17.46
Final Exams										
Final Exams	344	4.84	5.32	4.32	**	25.29	20.35	16.86	18.60	18.90
FinalExplenatory	282	4.96	5.29	4.47	**	6.32	54.65	12.27	16.73	10.04
Same semester (other course)										
BA107.FinalExams	236	5.54	5.66	5.31		13.33	10.22	34.67	26.67	15.11
Six months later (other courses)										
DMY.FinalExams	202	4.86	5.06	4.38		28.22	19.80	20.30	17.82	13.86
BA157.FinalExams	211	4.97	5.19	4.48	.	25.87	0.00	35.82	27.36	10.95
BA108.FinalExams	205	5.76	6.12	5.03	**	7.43	27.72	29.70	22.77	12.38
One year later (other courses)										
SAD.FinalExams	239	4.62	5.07	3.94	**	26.78	26.78	19.67	15.90	10.88
BA199.FinalExams	172	5.24	5.39	4.76		10.18	25.75	37.72	17.96	8.38

Table 5 illustrates students' final exam grades for the above courses. It is noted that columns in Table 5 are the same as these appeared in Table 1. It emerges that students who participated in the flipped classroom performed better on average in all the courses examined.

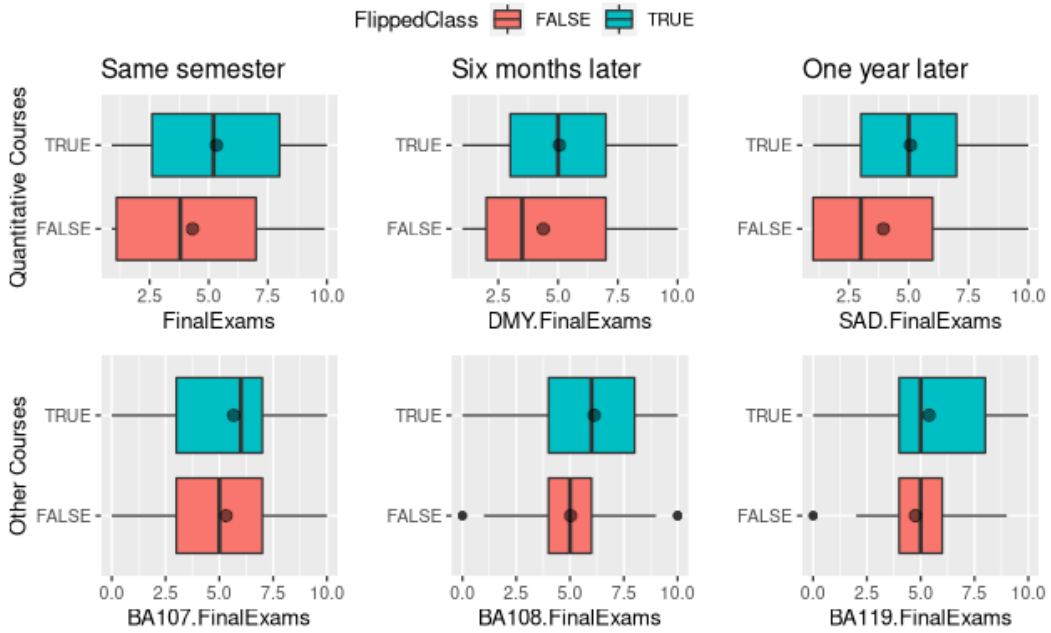

Figure 7. Grades of Students in the Final Exams of Six Courses of the 1st, 2nd and 3rd Academic Semester

Figure 7 presents the boxplots for the grades of students' grades in final exams of six courses, two courses from each semester for the first three academic semesters. The first row shows the courses that belong to the cognitive subject of quantitative methods (mathematics and statistics) for the 1st, 2nd, and 3rd semesters, while the second row shows courses of other cognitive subjects of the first three academic semesters. It is noticed that the gray dot in every subgraph denotes the mean value of the final exam grade.

In Figure 7 it is illustrated that in the courses of quantitative methods (upper row of subgraphs) the students who participated in the flipped classroom continued to have better performance compared with those who did not participate in. In addition, the interquartile range (width of cyan and pink orthogonal boxes) of the case studies of the students in the flipped classroom is less than that of those who did not participate in the flipped classroom. Moreover, the effect of the flipped classroom on students' performance seems to acquire a character of a permanent duration in the courses of mathematics. In further, in the rest of the courses (lower row of subfigures) the differences in students' performance are smaller, with a tendency to shrink. This could be interpreted as a kind of positive change in their learning approach towards mathematics, indeed maintained in the remaining courses for up to one year later.

5. Discussion

The aim of the present research is to examine the effect of the proposed PL-FC model on students' academic performance during the semester as well as on the final exam level of

Calculus and in subsequent courses up to one year later. The main pillars of the proposed flipped classroom model are cooperative learning before and outside the classroom and group peer-tutoring within it. The former is not common; however, it is part of the present study's educational experiment because in combination with the latter they structure the construct of the positive correlation of the flipped classroom with the academic performance of students mainly via the encouragement of students group interaction.

However, the research of Fung et al. (2021) indicated that the effect of the flipped classroom on mathematics is still unclear in terms of students' academic performance and their perceptions to (Fung, Besser, and Poon, 2021). Research further indicated that the effective flipped classroom brings the best academic result in comparison to the traditional approach, consisting of discussion, teacher's feedback, and teamwork work with fellow students. Similarly, the rationale for shaping the PL-FC model of the present work was the emphasis on collaborative work between students, inside and out of the classroom, expressed through cooperative learning and group peer-tutoring.

According to Enfield (2013), the characteristic of the collaborative nature of the flipped classroom is very essential as it offers students the opportunity to acquire skills and abilities based on the learning and collaboration that develops between them (Enfield, 2013).

The results of the flipped classroom on student performance compared to the traditional are mixed (Morton and Colbert-Getz, 2017); other surveys indicate a positive correlation (Tune, Sturek, and Basile, 2013), while others show a neutral effect (Lape et al., 2014). Indicatively, the flipped classroom is intended for students to perform the functions of application, analysis, and evaluation of material and therefore, tasks exclusively requiring material recall are unlikely to have a positive result within flipped classroom compared to the traditional. However, there is the other side of the coin; although some educators believe in the positive effect of the flipped classroom on student's advancement in mathematics, this effect is still weak (Lelean and Edwards, 2020; Lo and Hew, 2017; Strelan, Osborn, and Palmer, 2020; Van Alten et al., 2019; Wagner, Gegenfurtner, and Urhahne, 2020; Fung, Besser, and Poon, 2021).

The present research reveals that students who participated in the PL-FC model performed better in the final exams of Calculus at the end of the academic semester compared to those who did not participate in. Therefore, the answer to the first research question reveals a positive correlation between the application of the PL-FC model and students' participation in it. Accordingly, based on Stockwell et al. (2015) finding students who were involved in the flipped classroom showed a better performance in the final exams compared with those who did not participate (Stockwell et al., 2015).

Antidiametrically, according to Morton & Colbert - Getz (2017) the flipped classroom compared to the traditional lecture, did not make any difference in terms of equipping students with the ability to apply the material to the final exam. Also, the flipped classroom compared to the traditional has no difference in the effect of recalling or recognizing the material in the final exam (Morton and Colbert-Getz, 2017). Similarly, based to Fautch (2015) there was no differentiation emerged in the performance of students involved in the flipped

classroom in terms of the final examination (Fautch, 2015; Morton and Colbert-Getz, 2017). In the same line of argument, according to Blair et al. (2016) no significant difference was found in the flipped classroom's application to students' performance in the exams, while the students in the flipped classroom who achieved high grades were few (Blair, Maharaj, and Primus, 2016). Indeed, a number of studies have not shown a difference in student performance within the flipped classroom in comparison with the traditional in various subjects (Morton and Colbert-Getz, 2017; McLaughlin et al., 2013; Lape et al., 2014; Fitzgerald and Li, 2015) including the undergraduate mathematics course (Morton and Colbert-Getz, 2017; Lape et al., 2014).

Meanwhile, according to Morton & Colbert-Getz (2017) the flipped classroom if compared to the traditional enhances students' ability to analyze the material in the final exam (Morton and Colbert-Getz, 2017). Indeed, in the present research and in response to the second research question, students who participated in the PL-FC model answered the problem solving -open-ended question- better in the final exam. That is, the students who participated in the flipped classroom performed better on problem-solving in mathematics, formulating, analyzing, interpreting, expressing, and developing their mathematical thoughts better even in different contexts encompassing mathematics compared with those who did not participate in the flipped classroom. In the same line of argumentation, through the practice of the flipped classroom, the difficulty of students to remain vigilant in the classroom is addressed (Jungić et al., 2015), and also via the high communication level within the classroom, the comprehension of the lecture's content is further encouraged (Wasserman et al., 2017; Feudel and Fehlinger, 2021). Furthermore, in the present work, it emerged that students who participated in the proposed flipped classroom model gradually showed an advancement in their performance on the exercises of each chapter examined during the academic semester. Therefore, in addition to the grade in the final exams of the semester where they scored better, their performance in the individual exercises of the thematic units was constantly improving gradually.

In addition, in the context of the investigation of the third research question of the present work, it appears that the effect of the flipped classroom with the methodology applied contributes to a more permanent character of better student performance in mathematics.

It is interesting the detail emerged in regards to the "non-temporary" effect of the flipped classroom on the benefits of students permitting in a way the connection of their participation in the flipped classroom with certain skills' reinforcement which continue to exist even after the end of the academic semester. The maintenance of this "skills supply" is reflected mainly in the academic performance of students progressively during and after the academic semester, extended also in courses of other cognitive subjects beyond mathematics. Towards this direction, in the present research and in the context of the fourth research question's investigation, a positive effect was identified on the academic performance of students in mathematics and other cognitive subjects; this is due mainly to the inducement of students' active role in the learning process and therefore their study.

Therefore, it seems that the flipped classroom process had two important effects on the

academic image of the students who participated in it. The first is in regards to the change of attitude towards the courses of mathematics and the second has to do with their overall motivation in the cognitive subjects apart from mathematics.

Moreover, it emerged that in the courses of quantitative methods (mathematics and statistics) during the first three academic semesters, the students who participated in the flipped classroom continued to have better performance compared with those who did not participate. In addition, considering that the intercept is 4.3, it is noticed that the students who participated in flipped classroom even with a medium performance as tutors, had a higher than average score in the final exams.

Of particular interest is the argument supporting the progressive movement from the traditional approach to the flipped classroom, as if this progressiveness doesn't exist then this can lead to negative emotions due mainly to the lack of familiarity with the instructions and the content taught to the students; so the "relaxed" atmosphere is likely to occur undermining the learning outcomes (Lo, Hew, and Chen, 2017; Boevé et al., 2017; Strayer, 2012; Fung, Besser, and Poon, 2021). One possible way to incorporate innovative teaching strategies is to supplement the traditional lecture with new methods rather than completely replace the latter (Missildine et al., 2013). Indicatively, according to Lombardini et al (2018), two flipped classrooms were designed, the partially flipped and the full flipped in order to examine student's performance in a microeconomics course leading to the finding that students have not been satisfied with the full flipped as happened with the partial because of the workload (Lombardini, Lakkala, and Muukkonen, 2018; Zhao, He, and Su, 2021). In the present research the traditional lecture was not sidelined, on the contrary it was part of the educational process.

In general, it is important for the teacher to emphasize the configuration of the learning environment and to listen to students' approach to learning, in the context of pedagogical decision making (Blair, Maharaj, and Primus, 2016); especially in subjects such as mathematics often perceived by students as a subject with complexity (Gafoor and Sarabi, 2015; Fung, Besser, and Poon, 2021).

5.1 Limitations

A limitation of the present study is that it was carried out during the academic year 2020-2021 when restrictive measures against the Covid-19 pandemic were implemented. Therefore, the proposed flipped classroom model was mainly employed as a distance learning tool lacking the ideal circumstances of more intense interpersonal interactions inside the classroom.

5.2 Theoretical Implications

The present study contributes to the existing literature by enhancing the research on the positive effect of the flipped classroom on students' academic performance. Parameters emerge in the context of the PL-FC model application exerting their role, such as learning autonomy, teamwork, student motivation, cooperative learning, and group peer-tutoring. Group out-class activities were integrated into the PL-FC model on the ground of the flipped

classroom pedagogy; perspective not adequately being investigated so far, as it has come to our knowledge.

5.3 Practical Implications

The proposed PL-FC model enables students to perceive and solve problems within their peer groups, as well as to function autonomously in their individual learning. More broadly, students and teachers benefit from peer learning in terms of the flipped classroom which via the PL-FC model can improve the academic performance and experience.

6. Conclusion and Further Research

The educational planning in higher education shows diversity in content (Lea and Callaghan, 2008), social norms, beliefs, local stories, and existing systems (Blair, Maharaj, and Primus, 2016).

The main findings of the present study focus on the positive effect of the proposed PL-FC model on students' performance in mathematics on the level of grades in the final exams as well as via the intermediate examinations. It is of interest that students who participated in the PL-FC model maintain a good level of performance over time equipping students with the mechanism to cope with the study obligations, the academic requirements and learning experiences.

Cooperative learning outside and before the classroom and group tutoring inside the classroom consist simultaneously the two parallel pillars of the proposed flipped classroom model; students' learning experience is further reinforced via peer learning emphasizing a novelty element of the present work.

The study of the flipped classroom on the basis of existing solid research approaches is important and at the same time needs further investigation with a view to extract the usefulness of the pedagogical method towards the quality of educational processes' improvement and learning outcomes' achievement.

Future research could focus on students' differences in background, interests, intentions and the so-called "ability" and their effect on the conditions of flipped classroom interactions. In addition to the quantitative approach, the qualitative could be conducted to enlighten different aspects of the proposed PL-FC model's effects on student learning processes. In further, it is crucial to examine the permanent character of the proposed model effect on students' academic performance, through its examination during the entire period of studies.

References

Alrø, H., & Ole, S. (2004). Dialogue and Learning in Mathematics Education: Intention, Reflection, Critique. Vol. 29. Springer Science & Business Media.

Androulakis, G. S., Dimitra, Ap. G., Pantelis, K., and George Stamelos. (2021). The role of

the academic factor in student's tendency to university dropout. *Journal of Education and Human Development, 10*(1), 1-18. http://dx.doi.org/10.15640/ jehd.v10n1a5

Artigue, M. (2001). *What Can We Learn from Educational Research at the University Level?* In The Teaching and Learning of Mathematics at University Level: An ICMI Study, edited by Derek Holton, Michèle Artigue, Urs Kirchgräber, Joel Hillel, Mogens Niss, and Alan Schoenfeld, 207-20. Dordrecht: Springer Netherlands. https://doi.org/10.1007/0-306-47231-7_21

Aust, F., & Marius, B. (2022). Papaja: Prepare Reproducible APA Journal Articles with r Markdown. Retrieved from https://github.com/crsh/papaja

Baker, J. W. (2000). "The" classroom flip." Using Web Course Manag. Tools to Become Guid. By Side, 9 – 17. Retrieved from https://digitalcommons.cedarville.edu/media_and_applied_communications_publications/15

Bergmann, J., & Aaron, S. (2012). Flip your classroom: Reach every student in every class every day. International society for technology in education. Retrieved from https://books.google.gr/books?id=-YOZCgAAQBAJ&hl=el

Bernard, J. S. (2015). The Flipped Classroom: Fertile Ground for Nursing Education Research. *Int. J. Nurs. Educ. Scholarsh., 12*(1), 99-109. https://doi.org/doi:10.1515/ijnes-2015-0005

Bishop, J., & Matthew, A. V. (2013). *The Flipped Classroom: A Survey of the Research. In 120th ASEE Annual Conference & Exposition*. Atlanta, Georgia: ASEE Conferences. https://doi.org/10.18260/1-2--22585

Blair, E., Chris, M., & Simone, P. (2016). Performance and perception in the flipped classroom. *Education and Information Technologies, 21*(6), 1465-82. 10.1007/s10639-015-9393-5

Boevé, A. J., Rob, R. M., Roel, J. B., Jorien, V., Rink, H., & Casper, J. A. (2017). Implementing the flipped classroom: an exploration of study behaviour and student performance. *Higher Education, 74*(6), 1015-32. https://doi.org/10.1007/s10734-016-0104-y

Boud, D. (1999). Situating academic development in professional work: Using peer learning. *International Journal for Academic Development, 4*(1), 3-10. https://doi.org/10.1080/1360144990040102

Brame, S. J. (2013). Flipping the Classroom. Retrieved from https://cft.vanderbilt.edu/guides-sub-pages/flipping-the-classroom/

Chua, J. S. M., & Fatimah, A. L. (2014). The flipped classroom: Viewpoints in Asian universities. *Educ. Med. J. 6*(4). Retrieved from http://eduimed.usm.my/EIMJ20140604/EIMJ20140604_02.pdf

Cobb, P., Ada, B., Kay, M., & Joy, W. (1997). Reflective Discourse and Collective Reflection. *Journal for Research in Mathematics Education JRME, 28*(3), 258-77. https://doi.org/10.5951/jresematheduc.28.3.0258

Comtois, D. (2021). Summarytools: Tools to Quickly and Neatly Summarize Data. Retrieved from https://github.com/dcomtois/summarytools

Danker, B. (2015). Using flipped classroom approach to explore deep learning in large classrooms. *IAFOR Journal of Education, 3*(1), 171-86.

De Backer, L., Hilde, V. K., & Martin, V. (2015). Promoting university students' metacognitive regulation through peer learning: the potential of reciprocal peer tutoring. *Higher Education, 70*(3), 469-86. https://doi.org/10.1007/s10734-014-9849-3

Enfield, J. (2013). Looking at the Impact of the Flipped Classroom Model of Instruction on Undergraduate Multimedia Students at CSUN. *TechTrends, 57*(6), 14-27. https://doi.org/10.1007/s11528-013-0698-1

Farren, P. (2016). Transformative Pedagogy in Context: being and becoming. *World Journal on Educational Technology: Current Issues, 8*(3), 190-204.

Fautch, J. M. (2015). The flipped classroom for teaching organic chemistry in small classes: is it effective? *Chemistry Education Research and Practice, 16*(1), 179-86. https://doi.org/10.1039/x0xx00000x

Felder, R. M., & Rebecca, B. (2001). Effective strategies for cooperative learning. *Journal of Cooperation & Collaboration in College Teaching*, *10*(2), 69-75.

Ferreri, S. P., & Shanna, K. O' C. (2013). Redesign of a Large Lecture Course into a Small-Group Learning Course. *American Journal of Pharmaceutical Education, 77*(1), 13. https://doi.org/10.5688/ajpe77113

Feudel, F., & Luise, F. (2021). Using a lecture-oriented flipped classroom in a proof-oriented advanced mathematics course. Int. J. Math. Educ. Sci. Technol., 1-28. Retrieved from https://www.tandfonline.com/action/showCitFormats?doi=10.1080/0020739X.2021.1949057

Fineman, S. (1981). Reflections on Peer Teaching and Peer Assessment: An Undergraduate Experience. *Assessment and Evaluation in Higher Education, 6*(1), 82-93.

Fitzgerald, N., & Luisa, L. (2015). Using presentation software to flip an undergraduate analytical chemistry course. ACS Publications. http://dx.doi.org/10.1021/ed500667c

Freitag, M. A. (2020). Note-Taking Practices of Students in College Mathematics. *Int. J. Res. Undergrad. Math. Educ., 6*(1), 65-89. https://doi.org/10.1007/s40753-019-00099-0

Fukawa-Connelly, T., Keith, W., & Juan, P. M-R. (2017). Informal Content and Student Note-Taking in Advanced Mathematics Classes. *J. Res. Math. Educ. JRME, 48*(5), 567-79. https://doi.org/10.5951/jresematheduc.48.5.0567

Fung, C-H., Michael, B., & Kin-Keung, P. (2021). Systematic literature review of flipped classroom in Mathematics. *EURASIA J. Math. Sci. Technol. Educ., 17*(6). https://doi.org/10.29333/ejmste/10900

Gafoor, K. A., & Sarabi, M. K. (2015). Nature of Mathematics That Impacts Difficulties in Learning It: A Comparison of Student Perspectives on Learning School Subjects from Kerala. Online Submission. Retrieved from https://eric.ed.gov/?id=ED581534

Giannakos, M. N., John, K., & Nikos, C. (2014). Reviewing the Flipped Classroom Research: Reflections for Computer Science Education. *In Proc. Comput. Sci. Educ. Res. Conf.,* 23–29. CSERC '14. New York, NY, USA: Association for Computing Machinery. https://doi.org/10.1145/2691352.2691354

Harel, G., & Jana, T. (1996). Higher Mathematics Education BT - International Handbook of Mathematics Education: Part 1. In, edited by Alan J Bishop, Ken Clements, Christine Keitel, Jeremy Kilpatrick, and Colette Laborde, 675-700. Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-009-1465-0_19

Herrmann, K. J. (2013). The impact of cooperative learning on student engagement: Results from an intervention. *Active Learning in Higher Education 14*(3), 175-87. https://doi.org/10.1177/1469787413498035

Hew, K. F., Shurui, B., Phillip, D., & Chung, K. L. (2021). Meta-analyses of flipped classroom studies: A review of methodology. *Educational Research Review, 33,* 100393. https://doi.org/10.1016/j.edurev.2021.100393

Hurtubise, L., Elissa, H., Leah, S., & Heeyoung, H. (2015). The Flipped Classroom in Medical Education: Engaging Students to Build Competency. *J. Med. Educ. Curric. Dev. 2 (January),* JMECD.S23895. https://doi.org/10.4137/JMECD.S23895

Jensen, J. L., Tyler, A. K., & Patricia, D. M. G. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. *CBE—Life Sciences Education 14*(1), ar5. https://doi.org/10.1187/cbe.14-08-0129

Johnson, D. W., & Roger, T. J. (2002). Learning Together and Alone: Overview and Meta‐analysis. *Asia Pacific Journal of Education, 22*(1), 95-105. https://doi.org/10.1080/0218879020220110

Jungić, V., Harpreet, K., Jamie, M., & Cindy, X. (2015). On flipping the classroom in large first year calculus courses. *Int. J. Math. Educ. Sci. Technol., 46*(4), 508-20. https://doi.org/10.1080/0020739X.2014.990529

Kagan, S., & Spencer, K. (1994). *Cooperative learning*. Kagan San Clemente, CA. Retrieved from https://www.kisii.gl/wp-content/uploads/2019/11/Kagan-Stenlev-Cooperative-Learning.pdf

Kaisari, M., & Tasos, P. (2010). So we decided to call 'straight line' (…): Mathematics students' interaction and negotiation of meaning in constructing a model of elliptic

geometry. *Educational Studies in Mathematics, 75*(3), 253-69. https://doi.org/10.1007/s10649-010-9255-4

Kassambara, A. (2020). Ggpubr: Ggplot2 Based Publication Ready Plots. Retrieved from https://rpkgs.datanovia.com/ggpubr/

Kaufman, D., Elliott, S., & Ken, D. (1997). Three approaches to cooperative learning in higher education. *Canadian Journal of Higher Education, 27*(2/3), 37-66.

Låg, T., & Rannveig, G. S. (2019). Does the flipped classroom improve student learning and satisfaction? A systematic review and meta-analysis. *AERA Open, 5*(3), 2332858419870489. http://doi.org/10.1177/2332858419870489

Lage, M. J., Glenn, J. P., & Michael, T. (2000). Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment. *J. Econ. Educ., 31*(1), 30-43. https://doi.org/10.1080/00220480009596759

Lape, N. K., Rachel, L., Darryl, H. Y., Karl, A. H., Rebecca, E., & Nancy, H. (2014). Probing the inverted classroom: A controlled study of teaching and learning outcomes in undergraduate engineering and mathematics. In 2014 ASEE Annual Conference & Exposition, 24-1006. Retrieved from https://peer.asee.org/probing-the-inverted-classroom-a-controlled-study-of-teaching-and-learning-outcomes-in-undergraduate-engineering-and-mathematics

Lea, S. J., & Lynne, C. (2008). Lecturers on teaching within the 'supercomplexity' of Higher Education. *Higher Education, 55*(2), 171. https://doi.org/10.1007/s10734-006-9041-5

Lelean, H., & Frances, E. (2020). The impact of flipped classrooms in nurse education. *Waikato J. Educ., 25*, 145-57.

Lew, K., Timothy, P. F-C., Juan, P. M-R., & Keith, W. (2016). Lectures in Advanced Mathematics: Why Students Might Not Understand What the Mathematics Professor Is Trying to Convey. *J. Res. Math. Educ. JRME, 47*(2), 162-98. https://doi.org/10.5951/jresematheduc.47.2.0162

Lin, H-C, & Gwo-Jen, H. (2019). Research trends of flipped classroom studies for medical courses: a review of journal publications from 2008 to 2017 based on the technology-enhanced learning model. *Interact. Learn. Environ., 27*(8), 1011-27. https://doi.org/10.1080/10494820.2018.1467462

Littman-Ovadia, H., & Pavel, F. (2022). Paired learning duration and character strengths use as predictors of learning satisfaction: a dyadic longitudinal study among Chevruta students in Yeshivas. *Higher Education, 83*(3), 655-72. https://doi.org/10.1007/s10734-021-00690-y

Lo, C. K., & Khe, F. H. (2017). A critical review of flipped classroom challenges in K-12 education: possible solutions and recommendations for future research. *Res. Pract. Technol. Enhanc. Learn., 12*(1), 4. https://doi.org/10.1186/s41039-016-0044-2

Lo, C. K., Khe, F. H., & Gaowei, C. (2017). Toward a set of design principles for mathematics flipped classrooms: A synthesis of research in mathematics education. *Educational Research Review, 22*, 50-73. https://doi.org/10.1016/j.edurev.2017.08.002

Lombardini, C., Minna, L., & Hanni, M. (2018). The impact of the flipped classroom in a principles of microeconomics course: evidence from a quasi-experiment with two flipped classroom designs. *International Review of Economics Education, 29*, 14-28. https://doi.org/10.1016/j.iree.2018.01.003

Love, B., Angie, H., Neal, G., & Andrew, W. S. (2014). Student learning and perceptions in a flipped linear algebra course. *Int. J. Math. Educ. Sci. Technol., 45*(3): 317-24. https://doi.org/10.1080/0020739X.2013.822582

Martin, L., & Dave, T. (2019). Teaching with Teams: An introduction to teaching an undergraduate law module using Microsoft Teams. *Innovative Practice in Higher Education, 3*(3). Retrieved from http://journals.staffs.ac.uk/index.php/ipihe/article/view/188

McGhie, V. (2017). Entering university studies: identifying enabling factors for a successful transition from school to university. *Higher Education 73*(3), 407-22. https://doi.org/10.1007/s10734-016-0100-2

McLaughlin, J. E., LaToya, M. G., Denise, A. E., Christopher, A. D., Dylan, M. G., Mary, T. R., Nastaran, G., & Russell, J. M. (2013). Pharmacy student engagement, performance, and perception in a flipped satellite classroom. *American Journal of Pharmaceutical Education, 77*(9).

Michael, J. (2006). Where's the evidence that active learning works? *Advances in Physiology Education, 30*, 159-67. https://doi.org/10.1152/advan.00053.2006.

Missildine, K., Rebecca, F., Lynn, S., & Kevin, G. (2013). Flipping the classroom to improve student performance and satisfaction. *Journal of Nursing Education, 52*(10), 597-99. https://doi.org/10.1007/s10639-015-9393-5

Moffett, J. (2015). Twelve tips for 'flipping' the classroom. *Medical Teacher, 37*(4), 331-36. https://doi.org/10.3109/0142159X.2014.943710

Moffett, J., & Aileen, C. M. (2014). Evaluation of the flipped classroom approach in a veterinary professional skills course. Advances in Medical Education and Practice 5 (November), 415-25. https://doi.org/10.2147/AMEP.S70160

Moravec, M., Adrienne, W., Nancy, A-R., & Diane, K. O'. (2010). Learn before lecture: A strategy that improves learning outcomes in a large introductory biology class. *CBE—Life Sci. Educ., 9*(4), 473-81. https://doi.org/10.1187/cbe.10-04-0063

Morton, D. A., & Jorie, M. C-G. (2017). Measuring the impact of the flipped anatomy classroom: The importance of categorizing an assessment by Bloom's taxonomy. *Anat. Sci. Educ., 10*(2), 170-75. https://doi.org/10.1007/s10639-015-9393-5

Moust, J. C., & Henk, G. S. (1994). Effects of staff and student tutors on student achievement. *Higher Education, 28*(4), 471-82. https://doi.org/10.1007/BF01383938

Network, F. L. (2014). The four pillars of FLIP. Retrieved from https://www.flippedlearning.org/wp-content/uploads/2016/07/FLIP_handout_FNL_Web.pdf

Nouri, J. (2016). The flipped classroom: for active, effective and increased learning – especially for low achievers. *International Journal of Educational Technology in Higher Education, 13*(1), 1-10. https://doi.org/10.1186/s41239-016-0032-z

O'Flaherty, J., & Craig, P. (2015). The use of flipped classrooms in higher education: A scoping review. *Internet High. Educ., 25*, 85-95. https://doi.org/10.1016/j.iheduc.2015.02.002

Ojalvo, H. E., & Shannon, D. (2011). Five Ways to Flip Your Classroom with the New York Times. Retrieved from https://learning.blogs.nytimes.com/2011/12/08/five-ways-to-flip-your-classroom-with-the-new-york-times/?_php=true&_type=blogs&_r=1

Pierce, R., & Jeremy, F. (2012). Vodcasts and Active-Learning Exercises in a 'Flipped Classroom' Model of a Renal Pharmacotherapy Module. *Am. J. Pharm. Educ., 76*(10), 196. https://doi.org/10.5688/ajpe7610196

Postareff, L., Markus, M., Sari, L-Y, & Telle, H. (2017). The complex relationship between emotions, approaches to learning, study success and study progress during the transition to university. *Higher Education, 73*(3), 441-57. https://doi.org/10.1007/s10734-016-0096-7

Prober, C. G., & Salman, K. (2013). Medical education reimagined: a call to action. *Academic Medicine, 88*(10), 1407. 10. 10.1097/ACM.0b013e3182a368bd

R Core Team. (2022). R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Revelle, W. (2022). Psych: Procedures for Psychological, Psychometric, and Personality Research. Retrieved from https://personality-project.org/r/psych-manual.pdf

Roehl, A., Shweta, L. R., & Gayla, J. S. (2013). The flipped classroom: An opportunity to engage millennial students through active learning strategies. *J. Fam. Consum. Sci., 105*(2), 44-49. Retrieved from https://www.kent.ac.uk/teaching/documents/academic-practice/RoehlReddySHannon (2013) The flipped classroom as a way of engaging the Millenial through active learning strategies.pdf

Roger, T., & David, W. J. (1994). An overview of cooperative learning. Creativity and Collaborative Learning, 1-21. Retrieved from https://web.archive.org/web/20181123104309id_/http://digsys.upc.es:80/ed/general/Gasteiz/docs_ac/Johnson_Overview_of_Cooperative_Learning.pdf

Sahin, A., Baki, C., & Yunus E Zeytuncu. (2015). Flipping a College Calculus Course: A Case Study. *J. Educ. Technol. Soc. 18*(3), 142-52.

Samaila, K., Mona, M., & Kien, Tsong, C. (2021). Using Flipped Classroom Model: Factors Influencing Students' Satisfaction. *Eur. J. Interact. Multimed. Educ. 2*(2), e02112. https://doi.org/10.30935/ejimed/11260

Setyawan, F., & Siti, N. R. (2021). Conceptual Understanding of Complex Analysis Number using Flipped Learning. *IndoMath: Indonesia Mathematics Education 4*(1), 56-65.

Sharma, N., Lau, C. S., Iain, D., & Darren, H. (2015). How we flipped the medical classroom. *Medical Teacher, 37*(4): 327-30. https://doi.org/10.3109/0142159X.2014.923821

Skovsmose, O. (1994). Towards a critical mathematics education. *Educ. Stud. Math., 27*(1), 35-57. https://doi.org/10.1007/BF01284527

Slavin, R. E. (1980). Cooperative Learning. *Review of Educational Research, 50*(2), 315-42. https://doi.org/10.3102/00346543050002315

Stanley, D. (2021). apaTables: Create American Psychological Association (APA) Style Tables. Retrieved from https://github.com/dstanley4/apaTables

Stockwell, Bren. R., Melissa, S. S., Michael, C., & Elise, J. (2015). Blended learning improves science education. *Cell, 162*(5), 933-36. http://dx.doi.org/10.1016/j.cell.2015.08.009

Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15*(2), 171-93. https://doi.org/10.1007/s10984-012-9108-4

Street, S. E., Kurt, O. G., Cheryl, M., & Kenneth, R. (2015). The flipped classroom improved medical student performance and satisfaction in a pre-clinical physiology course. *Medical Science Educator, 25*(1), 35-43. https://doi.org/10.1007/ s40670-014-0092-4

Strelan, P., Amanda, O., & Edward, P. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. *Educational Research Review, 30*, 100314. https://doi.org/10.1016/j.edurev.2020.100314

Tang, T., Atef, M. A., Melad, O., Dana, M. O., Maged, A., & Ebrahim, B. (2020). Efficiency of flipped classroom with online-based teaching under COVID-19. *Interactive Learning Environments, September*, 1-12. https://doi.org/10.1080/10494820.2020.1817761

Topping, K. J. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. *Higher Education, 32*(3), 321-45. https://doi.org/10.1007/BF00138870

———. (2005). rends in Peer Learning. *Educational Psychology, 25*(6), 631-45. https://doi.org/10.1080/01443410500345172

Tune, J. D., Michael, S., & David, P. B. (2013). Flipped classroom model improves graduate

student performance in cardiovascular, respiratory, and renal physiology. *Advances in Physiology Education, 37*(4), 316-20. 10.1152/advan.00091.2013

Van, A., David, C. D., Chris, P., Jeroen, J., & Liesbeth, K. (2019). Effects of flipping the classroom on learning outcomes and satisfaction. *A meta-analysis. Educational Research Review, 28*, 100281. https://doi.org/10.1016/j.edurev.2019.05.003

Wagner, M., Andreas, G., & Detlef, U. (2020). Effectiveness of the flipped classroom on student achievement in secondary education: A meta-analysis. *Zeitschrift für Pädagogische Psychologie, 35*, 11-31. https://doi.org/10.1024/1010-0652/ a000274

Ward, M., Mary, C. K., & Candice, W. L. (2018). The flip side of traditional nursing education: A literature review. *Nurse Educ. Pract., 29*, 163-71. https://doi.org/10.1016/j.nepr.2018.01.003

Wasserman, N. H., Christa, Q., Scott, A. N., & Thomas, C. (2017). Exploring Flipped Classroom Instruction in Calculus III. *Int. J. Sci. Math. Educ., 15*(3), 545-68. https://doi.org/10.1007/s10763-015-9704-8

Wickham, H. (2016). *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. Retrieved from https://ggplot2.tidyverse.org

Wickham, H., & Jennifer, B. (2022). Readxl: Read Excel Files. Retrieved from https://CRAN.R-project.org/package=readxl

Wickham, H., Winston, C., Lionel, H., Thomas, L. P., Kohske, T., Claus, W., Kara, W., Hiroaki, Y., & Dewey, D. (2021). Ggplot2: Create Elegant Data Visualisations Using the Grammar of Graphics. Retrieved from https://CRAN.R-project.org/package=ggplot2

Wickham, H., Jim, H., & Jennifer, B. (2022). Readr: Read Rectangular Text Data. https://CRAN.R-project.org/package=readr

Wingate, U. (2007). A framework for transition: Supporting ‘learning to learn’ in higher education. *Higher Education Quarterly, 61*(3), 391-405.

Wood, B. B. (2001). Stake’s Countenance Model: Evaluating an Environmental Education Professional Development Course. *The Journal of Environmental Education, 32*(2), 18-27. https://doi.org/10.1080/00958960109599134

Zainuddin, Z., & Siti, H. H. (2016). Flipped Classroom Research and Trends from Different Fields of Study. *Int. Rev. Res. Open Distrib. Learn., 17*(3), 313-40. https://doi.org/10.19173/irrodl.v17i3.2274

Zhao, L., Wei, H., & Yu-Sheng, Su. (2021). nnovative pedagogy and design-based research on flipped learning in higher education. *Frontiers in Psychology, 12*, 230. https://doi.org/10.1016/j.xjep.2017.12.010

Zheng, B., & Yining, Z. (2020). Self-regulated learning: the effect on medical student learning outcomes in a flipped classroom environment. *BMC Medical Education, 20*(1), 100. https://doi.org/10.1186/s12909-020-02023-6

Zhu, H. (2021). kableExtra: Construct Complex Table with Kable and Pipe Syntax. Retrieved from https://CRAN.R-project.org/package=kableExtra