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Impact of peers on educational outcomes in Economics

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Abstract

INTRODUCTION. This paper contributes to the study of peer interactions in the university classroom.

METHOD. We evaluate the effects of teamwork on individual academic performance in four Team Based Learning (TBL) courses in the degrees of Economics and Business Administration.

RESULTS. We found that the average grade of the rest of the team members has a significant and positive association with the grade of the individual student. The student's personal test score increases about 0.65 points for every 1-point increase in the average score of their teammates. This association remains positive and significant even when we include socio-demographic variables to control for individual characteristics. We also tested the heterogeneity of peer effects in relation to the ability of individual and team performance.

DISCUSSION. The results suggest there is no heterogeneity in individual ability; however, we found a positive or slightly negative difference in the magnitude of the peer effect for teams in the top/bottom quartile compared to teams in the middle of the distribution.

Keywords

Peer effects; Team Based Learning; Active learning; Teamwork; Economics.

Recommended reference

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UNIVERSITAT DE BARCELONA

Títol (català)
Impacte entre iguals als resultats educatius en Economia

Resum
INTRODUCCIÓ. Aquest article aprofundeix en l'estudi de les interaccions entre iguals a l'aula universitària.

MÈTODE. Avaluem els efectes del treball en equip en el rendiment acadèmic individual en quatre assignatures que utilitzen l'aprenentatge basat en equips (ABE) dels graus d'Economia i d'Administració d'Empreses.

RESULTATS. Trobem que les qualificacions individuals dels estudiants tenen una associació positiva i significativa amb la qualificació mitjana de la resta de membres de l'equip. La puntuació pròpia de l'estudiant augmenta aproximadament 0,65 punts per cada augment d'1 punt a la nota mitjana dels companys d'equip. Aquesta associació continua sent positiva i significativa fins i tot quan incloem variables sociodemogràfiques per controlar les característiques individuals. També contrastem l'heterogeneïtat dels efectes dels companys segons la capacitat de rendiment individual i d'equip.

DISCUSSIÓ. Els resultats suggereixen que no hi ha heterogeneïtat en la capacitat individual, però trobem una diferència positiva o lleugerament negativa en la magnitud de l'efecte del treball entre iguals per als equips que es troben en el quartil superior/inferior, en contrast amb els equips que es troben al mig en la distribució.

Paraules clau
Efectes entre iguals; Aprenentatge en equip; Aprenentatge actiu; Treball en equip; Economia

Título (castellano)
Impacto entre iguales en los resultados educativos en Economía

Resumen
INTRODUCCIÓN. Este artículo profundiza en el estudio de las interacciones entre iguales en el aula universitaria.

MÉTODO. Evaluamos los efectos del trabajo en equipo en el rendimiento académico individual en cuatro asignaturas que emplean el Aprendizaje Basado en Equipos (ABE) de los grados de Economía y Administración de Empresas.

RESULTADOS. Encontramos que la calificación promedio del resto de los miembros del equipo tiene una asociación positiva y significativa con las calificaciones individuales de los estudiantes. La puntuación de la prueba del estudiante aumenta aproximadamente 0,65 puntos por cada aumento de 1 punto en la nota promedio de sus compañeros de equipo. Esta asociación sigue siendo positiva y significativa, incluso cuando incluimos variables sociodemográficas para controlar las características individuales. También probamos la heterogeneidad de los efectos de los pares por nivel de desempeño individual y de equipo.

DISCUSIÓN. Los resultados sugieren que no hay heterogeneidad en la capacidad individual, pero encontramos una diferencia positiva o ligeramente negativa en la magnitud del efecto de los pares para los equipos en el cuartil superior/inferior en relación con los equipos en el medio de la distribución.

Palabras clave
Efectos entre pares; Aprendizaje Basado en Equipos; Aprendizaje activo; Trabajo en equipo; Ciencias económicas

1. Introduction

Universities are currently in a process of transformation. Their general aim is to satisfy the students' expectations and the demands of today's society by improving the learning process, maintaining excellence and guaranteeing academic efficiency.

Adopting novel learning and teaching methodologies seems to be a logical step forward. Thus, in recent decades, student-centered teaching strategies have emerged in the university environment, such as team-based learning (TBL), the flipped classroom, project-based learning, and hybrid models.

One of the active learning and teaching methodologies that is gaining relevance in university settings is Team-Based Learning (TBL), which combines elements of the flipped classroom and collaborative work (Abio et al., 2019; Calimeris & Sauer, 2015; Cosgrove & Olitsky, 2014; Guo et al., 2020; Olitsky & Cosgrove, 2014, 2016; Oliván Blázquez et al., 2019; Swanson et al., 2019). As could be expected, this tendency has continued and expanded during the COVID-19 pandemic, although there are still few academic outcomes (Ahshan, 2021; Collado-Valero et al. 2021; Umar & Ko, 2022).

TBL takes advantage of peer learning by having students work in teams throughout the course. This methodology implies a paradigm shift from traditional lectures to a learning sequence structured in three phases. In the first phase, the student is exposed to the concepts of a given topic individually and outside the classroom. Next, in the second phase, multiple-choice tests based on assigned reading or other material that students have prepared are answered individually and in a team. In the third phase, the students, working in teams, solve practical problems in the classroom.[1]

There is increasing academic literature that analyzes the effects of peers in the application of active learning and teaching methodologies. Most of the studies reveal an improvement in academic performance and in the students' motivation and participation. In general, students show a favorable attitude and positively value their experiences with active methodologies. However, there are also studies that report null or even negative effects in terms of academic results. Furthermore, the peer effects may not be linear in relation to individual and team ability. There is also mixed empirical evidence on the nature of this behavior. Ficano (2019) found a negative impact of flipped learning for students with a low math level or who belong to minorities. In a quasi-experimental design, Emerson et al. (2015) did not find improvements in learning, interest or attitude in students who engaged in cooperative learning activities compared to those who worked individually.

It seems that active learning and teaching methodologies can encourage students to make more study effort and these methods also increase the students' motivation without negatively impacting performance, or, at best, improve their attitudes toward both learning and academic performance; however, the empirical findings are ambiguous. Therefore, further research is needed to provide more rigorous quantitative evidence, which is still relatively limited, on the impacts of methodologies like TBL on student outcomes.

In this paper we assess whether team learning has positive, negative, or no effect on individual performance. We also analyze the heterogeneity of the results, that is, whether peer effects depend on individual and team ability.

The data come from students taking the degrees of Economics and Business Administration at the University of Barcelona in various Economic Theory courses that started in the academic year 2013/14 and ended in

(1) A more detailed explanation of the TBL method can be found in Michaelsen et al. (2004) and Sibley et al. (2014). A comprehensive description of the methodology followed in the University of Barcelona can be found in Abio et al. (2019).

2017/2018. We analyze individual data from multiple-choice test grades, final exam grades and the overall course grade for all the students enrolled in the courses that adopted active methodologies during the study period. In addition, we included data for individuals from their academic records, such as the university entrance grade, the average grade of all courses of the previous academic year (GPA), and some socio-demographic characteristics such as sex, age, nationality and family background (studies and occupation of both parents).

We estimated several model specifications for fixed effects and random effects and found that the average grade of the rest of the team members is significantly and positively associated with the individual student's grades. The student's personal test score increased about 0.65 points for every 1-point increase in their teammates' average score. This association remains positive and significant even when we include socio-demographic variables to control for individual characteristics. We did not find heterogeneity in relation to the individual's ability; however, there is a small positive or negative difference in the magnitude of the peer effects for teams in the top/bottom quartile compared to teams in the middle of the distribution.

The rest of the paper is structured as follows. In section 2, we present a brief literature review on the topic. Section 3 describes the data used in the analyses. In Section 4, we set out the empirical strategy, and in section 5 we present the estimation results. Finally, in section 6 we make some concluding remarks.

2. Literature review

Team-Based Learning methodologies encourage peer interaction, which education experts consider to be one of the most effective instructional practices for quality education (Topping, 2001). Most studies show significant improvements in academic performance, motivation, and student participation when these new methodologies are applied compared to the exclusive use of the traditional teaching model based on face-to-face master classes (Abio et al., 2022; Nokes-Malach et al., 2015; Spinger et al., 1999; Wu, 2015). In general, students show a favorable attitude and positively value experiences with active methodologies (Abio et al., 2019, 2021; Bowen et al., 2014; Calimeris, 2018; Espey, 2010; Lage et al., 2000; Lombardini et al., 2018; Odell, 2018; Roach, 2014). For example, Calimeris and Sauer (2015) found that more than half of the students, 52%, prefer the flipped classroom format to the traditional format. Becker and Proud (2018) did not obtain consistent overall results, although they observed that the most involved students usually choose the active methodologies. However, other studies report no or even negative effects on academic outcomes (Alpert et al., 2016; Green, 2014; Joyce et al., 2015; Kwak et al., 2015; Olitsky & Cosgrove, 2014).

There is relatively little empirical evidence on the impact of peer learning on academic performance (Epple & Romano, 2011; Sacerdote, 2011). This is due, in part, to the difficulty of separating peer effects from selection effects, which are related to students choosing the universities where they study or the subjects they attend or groups (to a lesser extent) they mix with. The study of peer effects is also hindered by the mirror effect (or simultaneity problem), which reflects the idea that peer-to-peer interactions work in two ways: student performance depends on team members and, in turn, it affects peer performance, especially when teamwork takes place over an extended period of time (Manski, 1993). In addition, it is even more difficult to distinguish empirically between peer effects due to the individual's prior skills and knowledge and those due to individual behavior.

Most of the existing peer-effects literature uses data from U.S. universities and analyzes whether residential circumstances while studying influence academic performance. These studies, called roommate studies, share a key attribute, the random assignment into groups of students and their peers, that is, the random formation of peer groups. Most research shows that there are positive peer effects, but there are also studies that do not

observe any significant effects. For example, roommates' intellectual abilities have been related to the individual academic performance of their peers, but the direction of the effect can be positive or negative. Sacerdote (2001) and Zimmerman (2003) found that the members of a group of high-achieving students all tend to get better grades, while members of a group of less academically successful students all tend to get lower final results. Other studies find that low-achieving students benefit more (get better grades) if they have smart peers, and that the performance of good students is not harmed by having low-performing peers (Burke & Sass, 2013; Griffith & Rask, 2014). On the other hand, Lavy et al. (2012) report that having a large fraction of low-ability peers may significantly and negatively affect the performance of schoolmates, while average ability and the proportion of high-ability peers do not seem to matter. An important implication of these results is that peer effects may not be linear in terms of the ability of the individual and their peers. Therefore, the formation and composition of the teams becomes relevant for identifying peer effects on academic results.

This article aims to contribute to the existing literature on peer effects, which, as indicated above, is scarce and shows contradictory results.

3. Data

We study the effect of teamwork on individual performance using data from students enrolled in various Economic Theory courses in the degrees of Economics (Econ) and Business Administration (BA) at the University of Barcelona, Spain.[2] The selected courses used an active learning methodology during the study period, starting in the academic year 2013/14 and ending in 2017/18. We analyze data on individual grades of the multiple-choice tests taken during the course, the final exam and the overall course grade of all the students enrolled in the selected courses. In addition, we have individual data extracted from the academic records, such as the university entrance score, average grade of all courses of the previous academic year (GPA), and some socio-demographic characteristics such as sex, age, nationality and family background (studies and occupation of both parents). The data were provided by the Faculty of Economics and Business of the University of Barcelona.

The average class size was 67, ranging from 21 in Introduction to Economics 2013/14 to 107 in Microeconomics I 2017/18. In each course, students were randomly divided into teams of between 2 and 5 members.[3] The teams were not changed during the entire semester. Each student performed a total of 5 to 12 tasks during the course as established by the teacher, each consisting of individual and group work. The activities were quite homogeneous across the different subjects, consisting of problem sets with numerical and graphical exercises. The only difference was the number of assignments that were included in each course, although we do not think this could bias the results. In addition to these tasks, each student took a final exam. The overall course grade is the weighted average between the grades of the individual and group tasks and the grade of the final exam.

(2) The courses included in the analyses are: Introduction to Economics (Econ), Microeconomics (BA), Microeconomics I (Econ) and Microeconomics II (Econ). Each of these courses is taught either in the first or the second quarter of the academic year, depending on the subject. We implemented the active learning methodologies explained in the paper in a few selected sections of some Economic Theory subjects, in particular in the introductory courses. The specific periods in which the data were collected in each case depended on the instructors' availability and training possibilities, as this was a highly demanding teaching methodology and it was not possible to implement it in all sections of all courses.

(3) The creation of random groups was one of the most repeated complaints of the students, who wanted to choose their teammates. While some of the instructors agreed at a later stage to allow students to select their groups, these more recent experiences were not included in this study to avoid any biases in the results.

Table 1 summarizes the data for each course and academic year. Descriptive statistics on individual students and their teammates' grades are shown in Table 2.[4]

Table 1

Data description

	Course and academic period									
	INTRO_ECON	MICRO_BA			MICRO_I					MICRO_II
	2014-15	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16	2016-17	2017-18	2014-15
Number of students	21	85	56	89	76	54	47	60	107	77
Number of tasks	12	5	9	9	9	11	12	11	11	11
Number of observations	233	394	459	707	563	456	475	520	1,047	790

Note: The number of observations is lower than the number of students multiplied by tasks because there were individuals who did not have individual grades in some tasks.

Table 2

Descriptive statistics of individual grades by task

	Observations	Individual grades		Teammates' grades	
Task	(All students)	Mean	Std. Dev.	Mean	Std. Dev.
T01	611	4.81	2.22	4.76	1.70
T02	627	4.89	2.75	4.87	2.24
T03	630	5.75	2.33	5.73	1.72
T04	604	4.55	2.48	4.46	2.14
T05	596	4.23	2.36	4.17	1.91
T06	493	3.25	2.37	3.26	1.81
T07	492	4.14	2.98	4.08	2.51
T08	474	4.36	3.19	4.24	2.79
T09	488	4.37	2.86	4.21	2.40
T10	297	4.15	2.81	4.07	2.24
T11	276	2.32	2.19	2.24	1.83
T12	56	4.03	2.58	3.75	2.15
Final Exam	629	3.56	2.08	3.57	1.46
Course Grade	645	4.24	2.00	4.24	1.50

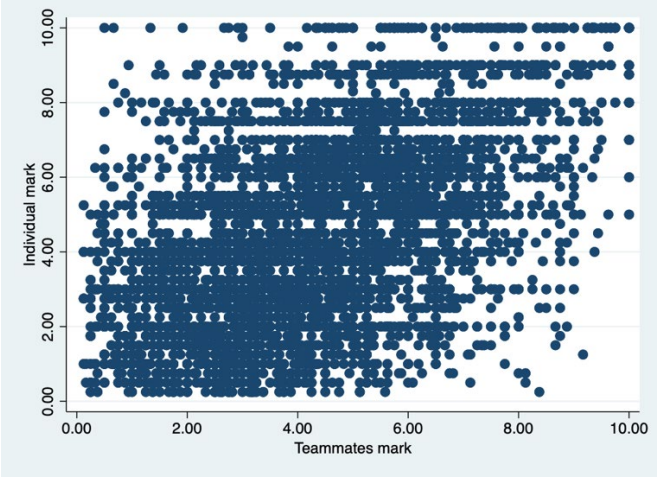
Since we aim to determine whether the individual student's performance is influenced by their teammates, we first looked at the raw association between the individual grade of each student (grade_i) and the average grade of their peers (grade_gi). The correlation coefficient shows a positive association between these two variables, considering the grades of the tasks, the final exam grade, and also the overall course grade (Figure 1).

Table 3 summarizes the descriptive statistics for these two primary variables that we used to estimate the peer effects on individual test scores.

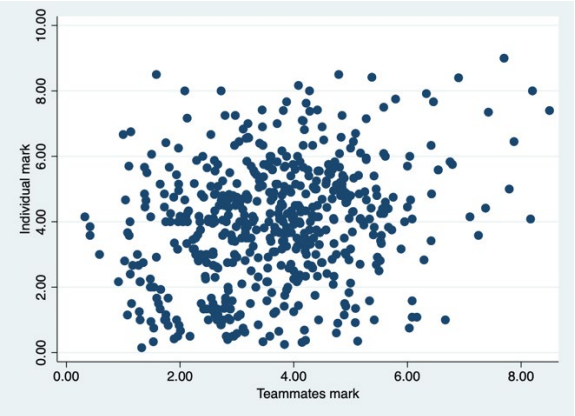
(4) Additional descriptive statistics are given in the Appendix.

Figure 1
Individual grades and teammates' average grades

a) Tasks correlation= 0.55



b) Final exam correlation= 0.25



c) Course grade correlation= 0.39

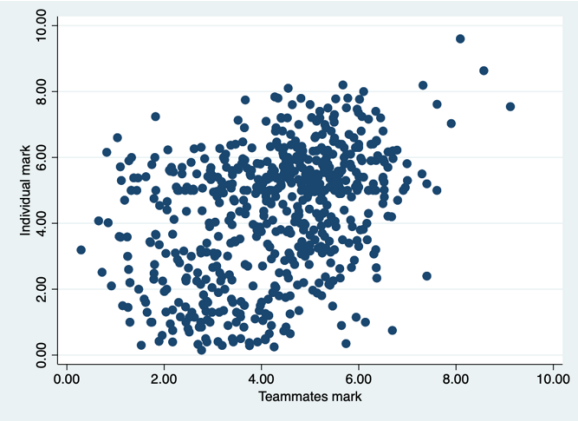


Table 3
Descriptive statistics

Variable		Mean	Std. Dev.	Min	Max	Observations	
grade_i	overall	4.4	2.71	-2.25	10	N =	5644
	between		1.35	0.05	7.82	n =	597
	within		2.38	-2.63	11.94	T-bar =	9.45
grade_gi	overall	4.3	2.27	-1.75	10	N =	6396
	between		1.08	1.46	7.26	n =	597
	within		2.01	-1.9	10.5	T-bar =	10.71

Notes: Only individual test scores are included. The number of observations is greater for the variable grade_gi since there are individuals who do not have individual grades in some tasks because they did not carry out the same ones.

4. Empirical strategy

The positive association between the individual grade of each student and the average grade of their teammates could be due to confounding factors. In order to determine whether the association holds, we followed Artz et al. (2016) and estimated the following model:

$$S_{ijk} = \alpha + \delta S_{j-i,k} + \beta \boldsymbol{X_i} + \varepsilon_{ijk}$$

in which the result of the evaluation S_{ijk} of a student i, who works in a group j, and carries out a task k, is explained by $S_{j-i,k}$, which obtains the results of the average score on test k of team j excluding individual i.

We consider $\boldsymbol{X_i}$, including a list of covariates to control for individual characteristics:

- Demographics: gender, age and nationality (Spanish versus Foreigner)
- Family background: studies and occupation of both parents
- Dyadic dummies for every course and academic period
- Student's academic background: university access score and average grade of other courses in the degree (GPA)
- Group quality: average grade of other courses in the degree of all members of the group (average GPA of teammates).

In order to evaluate whether the team effects vary according to the ability of individuals and the team performance, we also considered non-linearities in the association by looking at the interaction with a pair of dummies of both the student and group levels, as in Artz et al. (2016):

$$S_{ijk} = \alpha + \delta_0 S_{j-i,k} + \delta_1 S_{j-i,k} D_k^l + \delta_2 S_{j-i,k} D_k^h + \beta X_i + \varepsilon_{ijk}$$

In which D_k^l and D_k^h stand for low and high-performance dummies respectively, determining whether a student (or group) is in the bottom or top quartile of the distribution of the degree scores. Dummies for students take a value of 1 if the student´s GPA is in the bottom or top quartile of the distribution of individual GPAs. Dummies for teams take a value of 1 if the team's average score on the tasks is in the bottom or top quartile of the distribution of the teams' average scores on the tasks in the course, respectively.

5. Results

In Table 4 we first present the results of a random effects estimation, in which we include the proposed list of controls sequentially.[5] We can see a positive and significant association that remains even when a set of controls is included in the regression. The coefficient of peer effects in the full model (column 6) implies that a student's individual test score increases by 0.648 points for every 1-point increase in his or her teammate's average score.

(5) For brevity, we only include the results of the variable of interest, the average grade on test k of team j excluding individual i. Full results are available upon request.

Interestingly, the explanatory power of the results of the peers is surprisingly high (the R Squared of model 1 is over 0.32), which demonstrates that the group learning strategy plays a significant role.

Table 4
Random effects estimation

	(1)	(2)	(3)	(4)	(5)	(6)
grade_j-i	0.683***	0.683***	0.683***	0.635***	0.634***	0.648***
	(0.0162)	(0.0179)	(0.0181)	(0.0193)	(0.0193)	(0.0206)
Demographic controls	No	Yes	No	No	Yes	Yes
Family background	No	No	Yes	No	Yes	Yes
Course and year dummies	No	No	No	Yes	Yes	Yes
Student's academic background	No	No	No	Yes	Yes	Yes
Group quality	No	No	No	No	No	Yes
Observations	5,564	4,452	4,443	4,376	4,376	3,868
Students	597	437	436	429	429	373
R Squared	0.325	0.342	0.346	0.367	0.376	0.394

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1. Due to the lack of data available on some students, the column 6 estimation excludes individuals who are members of groups in which a single student has GPA data or when there are more than two students without available data in the team.

Next, we show the fixed effects estimates in order to isolate non-observable individual characteristics other than the ones we included in the previous regressions. Table 5 presents the results. Column (1) includes all individuals, while the estimates reported in column (2) refer to the sample of students with observable control variables. This allows us to make comparisons with the results of the random effects estimation, and clarifies the robustness of the results. The estimated parameter remains significant and positive, and, in fact, we obtain values very close to the ones observed in the random effects estimation. Finally, we divided the sample by tasks to determine whether there is a cumulative gain of the peer impact on the learning process. As it can be seen, both in the parameter estimates, and in the R Squared of the regressions, the peer effect increases over time, which is consistent with the design of the strategy. Since students remain with the same group throughout the semester, we can talk about a within-group "learning effect".[6]

In order to evaluate the heterogeneity of the peer effects in relation to individual ability and team performance, we included the interaction of the average grade of teammates, and the dummies for the lowest and highest quartiles of both the individual GPA and the group average grades in the course. Table 6 shows the results for the fixed effects and random effects estimations. In columns (1) and (2) we present the interaction with the quartiles of every student in the case of the fixed effects estimation and the random effects estimation, respectively. Columns (3) and (4) show the same estimations as the previous columns but for the quartiles of the average grades of every group. We cannot observe any significant differences between students in the low and high quartiles of the ability distribution. In terms of team performance, the random effects model suggests there is a significant, but very small, difference in the magnitude of the peer effect for teams in the top quartile or the bottom quartile of the distribution compared to teams in the middle of the distribution. The coefficient for low quartile teams is negative and significant at 10%; however, it is quantitatively very small, reducing the team impact on individual performance from 0.63 to 0.58. Similarly, the coefficient for the top quartile teams is positive

(6) We acknowledge the comment of an anonymous reviewer for stressing this outcome gained from the results.

and significant, but again, very small, increasing the team effect on individual performance from 0.63 to 0.67. We interpret these results as evidence that there is no substantive heterogeneity in peer effects.

Table 5

Fixed effects estimation. Full results and learning curve

	(1)	(2)	(3)	(4)	(5)
grade_j-i	0.683***	0.679***	0.542***	0.621***	0.766***
	(0.0174)	(0.0197)	(0.0368)	(0.0357)	(0.0230)
Sample	All	Only students with observable controls	All students, first 3 tasks	All students, tasks 4 to 6	All students, tasks 7 to 12
Observations	5,564	4,376	1,864	1,673	2,027
Students	597	429	596	582	491
R Squared	0.328	0.334	0.179	0.260	0.454

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 6

Fixed effects and random effects estimation. Individual and group heterogeneity of the peer effects

	FE (1)	RE (2)	FE (3)	RE (4)
grade_j-i	0.690***	0.649***	0.685***	0.632***
	(0.0277)	(0.0237)	(0.0234)	(0.0229)
Ability of student				
grade_j-i * Quartile 1 (lowest)	-0.0560	-0.0384		
	(0.0478)	(0.0308)		
grade_j-i * Quartile 3 (highest)	0.0254	0.0459		
	(0.0459)	(0.0298)		
Team performance				
grade_j-i * Quartile 1 (lowest)			-0.0767	-0.0551*
			(0.0467)	(0.0295)
grade_j-i * Quartile 3 (highest)			0.0450	0.0377*
			(0.0375)	(0.0213)
Control variables	No	Yes	No	Yes
Observations	4,452	3,868	5,564	3,868
Students	437	373	597	373
R Squared	0.336	0.395	0.329	0.397

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Finally, we also considered an alternative way of evaluating the TBL strategy. We used the final exam and the final grade of the course. As we have just one estimate for each student, we consider all controls we used in the random effects estimations and implement an OLS estimation. Table 7 shows the results of the final exam, while Table 8 displays the estimates of the overall course grade.

Table 7 shows that the peer impact of the final exam grade is initially significant and positive, although it vanishes as several controls are sequentially included. The overall course grade, which considers a weighted average of the final exam grade and the course's tasks, still captures the effect of the work carried out during the course, but clearly displays a much lower effect than the one observed in the fixed effects estimates. We do not observe a heterogeneous effect in relation to student ability in either of the estimations; however, heterogeneity in team performance seems to be relevant.

These results raise doubts about the overall peer effect of TBL on the individual learning process, as the summary evaluation reported in the final exam is not consistently significant in the estimated models. Consequently, the results observed in the estimations imply a positive but not long-lasting effect of the TBL strategy.

Table 7
OLS estimation. Final exam

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
grade_gi	0.333***	0.284***	0.273***	0.00335	-0.0222	0.00943	-0.134
	(0.0588)	(0.0651)	(0.0660)	(0.0751)	(0.0890)	(0.0892)	(0.0847)
Ability of student							
grade_j-i * Quartile 1 (lowest)						-0.0725	
						(0.0771)	
grade_j-i * Quartile 3 (highest)						-0.0465	
						(0.103)	
Team performance							
grade_j-i * Quartile 1 (lowest)							-0.228***
							(0.0715)
grade_j-i * Quartile 3 (highest)							0.148***
							(0.0556)
Demographic controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Family background	No	No	Yes	Yes	Yes	Yes	Yes
Course and year dummies	No	No	No	Yes	Yes	Yes	Yes
Student's academic background	No	No	No	Yes	Yes	Yes	Yes
Group quality	No	No	No	No	Yes	Yes	Yes
Observations	627	487	486	479	417	417	417
R-squared	0.055	0.056	0.107	0.286	0.275	0.278	0.320

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 8
OLS estimation. Overall grade of the course

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
nota_gi	0.528***	0.504***	0.498***	0.201***	0.238***	0.260***	0.0666
	(0.0487)	(0.0517)	(0.0539)	(0.0662)	(0.0794)	(0.0809)	(0.0740)
Ability of student							
grade_j-i * Quartile 1 (lowest)						-0.0553	
						(0.0551)	
grade_j-i * Quartile 3 (highest)						-0.00734	
						(0.0618)	
Team performance							
grade_j-i * Quartile 1 (lowest)							-0.160***
							(0.0493)
grade_j-i * Quartile 3 (highest)							0.151***
							(0.0382)
Demographic controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Family background	No	No	Yes	Yes	Yes	Yes	Yes
Course and year dummies	No	No	No	Yes	Yes	Yes	Yes
Student's academic background	No	No	No	Yes	Yes	Yes	Yes
Group quality	No	No	No	No	Yes	Yes	Yes
Observations	645	498	497	488	423	423	423
R-squared	0.154	0.176	0.222	0.374	0.382	0.384	0.427

Note: Robust standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

6. Discussion and conclusions

In this paper we study peer interactions in the university classroom. We assess the performance of students enrolled in various Economic Theory courses that applied Team-Based learning methodologies starting in the 2013/14 academic year and ending in the 2017/2018 academic year.

To determine the association between the individual grade and the teammates' average grade, we estimated several fixed effects and random effects models. We found that the average grade of the rest of the team members has a significant and positive effect on the individual student's grades. The student's personal test score increases about 0.65 points for every 1-point increase in their teammate's average score. This association remains positive and significant even when we include socio-demographic variables to control for individual characteristics.

We also evaluated whether the peer effects vary in relation to the individual's ability and the team's performance. Non-linearities in the association between the individual grade of each student and the average grade of their classmates were obtained by looking at the interaction with a pair of dummies of student ability and team performance. We found that there is no heterogeneity in the individuals' abilities, but there is a very small

positive/negative difference in the magnitude of the peer effects for teams in the top/bottom quartiles relative to teams in the middle of the distribution. This observed team performance heterogeneity could be a consequence of the way in which the groups were formed. The empirical evidence of peer effects shows that team construction and composition matters. In the TBL method, teams must be formed by the instructor in order to balance the expected performance of each team in the class. In this paper, however, data come from courses in which teams were formed by the students themselves. The association between the GPA of the student and the GPA of other peers in the group is 0.22. Although this is low, this association is statistically significant, which may influence the results in the regressions.

Finally, we evaluated the TBL strategy by considering the final exam and the overall course grade. The final grade OLS estimation still captures the effect of the work carried out during the course, but clearly displays a much lower effect than the one observed in the fixed effects estimations. The OLS estimation reveals that the peer impact of the final exam grade is initially significant and positive, although it disappears as several controls are sequentially included. The observed results raise doubts about the effect of TBL on the overall learning process. Altogether, the estimates suggest a positive peer-to-peer effect of the TBL strategy, but further research is needed regarding the heterogeneity and duration of this effect.

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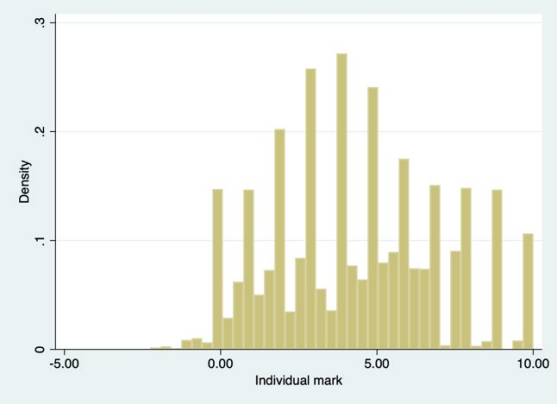
Appendix

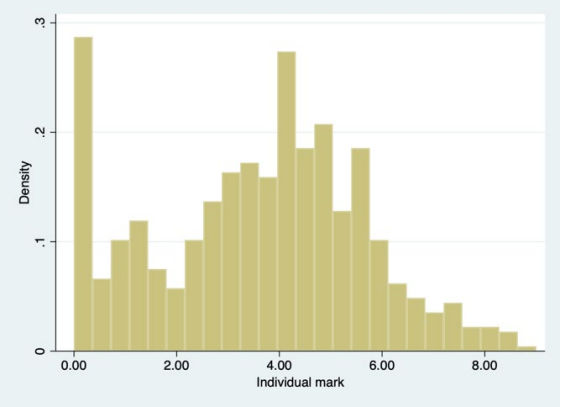
Figure A1
Frequency distribution of grades by task

a) Individual grades

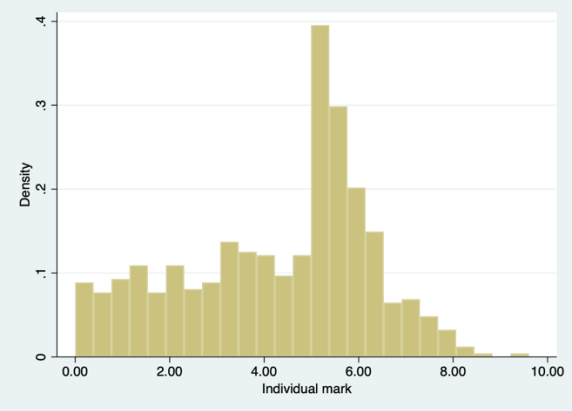
Problem sets



Final exam

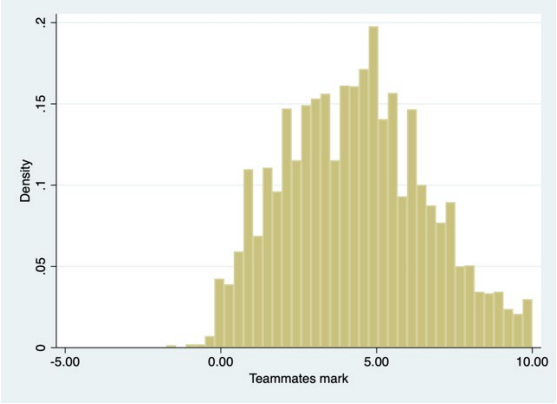


Final grade

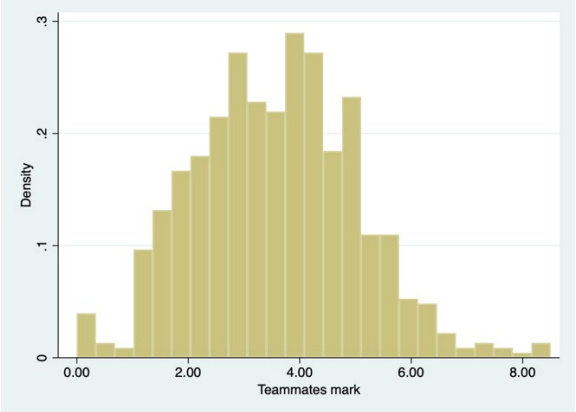


b) Teammates grades

Problem sets



Final exam



Final grade

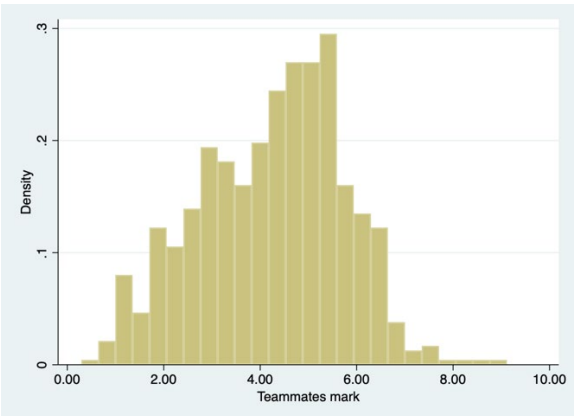


Table A1

Descriptive statistics on teams by course

	INTRO_ECON			MICRO_BA			MICRO_I			MICRO_II		
Team	Mean GPA / Std. dev.	Min/ Max	% Male	Mean GPA / Std. dev.	Min/ Max	% Male	Mean GPA / Std. dev.	Min/ Max	% Male	Mean GPA / Std. dev.	Min/ Max	% Male
1	6.03 .19	5.9 6.3	66.7	6 .28	5.8 6.6	58.1	5.68 .21	5.3 6	68.3	5.83 .21	5.5 6	50
2	5.63 .24	5.3 5.8	100	6.07 .21	5.8 6.3	0	5.68 .29	5.2 6.3	67.0	5.9 .11	5.8 6.1	80
3	5.9 .3	5.5 6.2	100	5.96 .36	5.5 6.8	54.4	5.82 .51	5 7.2	66.4	6.03 .49	5.5 6.8	50
4	5.63 .1	5.5 5.7	100	6.06 .23	5.7 6.4	66.7	5.81 .56	5.3 7.7	82.7	6.47 .29	6.1 6.8	33.3
5	5.55 .15	5.4 5.7	100	6.22 .28	5.9 6.7	100	5.86 .31	5.4 6.6	78.0	6.07 .49	5.6 6.7	75
6	5.63 .05	5.6 5.7	100	5.8 .14	5.7 6	66.7	5.84 .28	5.4 6.3	54.7	6 .31	5.5 6.3	75
7	5.67 .29	5.3 6	33.3	6.18 .23	5.8 6.4	25	6.12 .47	5.3 7.2	76.8	6.8 .74	6.1 7.8	0
8	. .			5.86 .1	5.7 6	51.2	5.65 .24	5.3 6.1	73.8	6.23 .27	6 6.6	33.3
9	. .			. .	. .	.	5.7 .27	5.2 6.1	80.2	6.1 .22	5.8 6.3	33.3
10	. .			6.13 .21	5.9 6.4	33.3	5.59 .3	5.1 6.1	79.6	6 .51	5.5 6.5	100
11	. .			5.85 .21	5.5 6.2	66.7	5.77 .27	5.3 6.3	76.8	6.5 .52	6 7.2	33.3
12	. .			6.23 .05	6.2 6.3	0	5.55 .24	5.1 5.9	62.3	6.16 .52	5.4 7	40
13	. .			6.1 .22	5.8 6.3	0	5.77 .27	5.3 6.3	94.6	. .	. .	.
14	. .			5.87 .17	5.7 6.1	33.3	5.87 .29	5.4 6.4	61.5	6.32 .36	5.8 6.7	75
15	. .			6.05 .15	5.9 6.2	50	5.87 .25	5.4 6.3	84.3	6.22 .27	5.8 6.5	75
16	. .			. .	. .	.	5.74 .26	5.4 6.4	91.9	6 .38	5.5 6.5	100
17	. .			6.2 .17	6 6.4	83.7	5.93 .33	5.5 6.6	60.3	5.95 .17	5.8 6.2	75
18	. .			6.3 .42	5.9 6.7	100	5.72 .28	5.3 6.3	80.7	5.83 .17	5.6 6	33.3
19	. .			6.13 .18	5.9 6.3	25	5.83 .47	5.1 6.5	75	6.26 .34	5.6 6.5	40
20	. .			. .	. .	.	5.98 .12	5.8 6.2	81.4	5.77 .49	5.4 6.6	50
21	. .			. .	. .	.	6.07 .19	5.8 6.2	100	. .	. .	.
Total	5.73 .26	5.3 6.3	85	6.03 .27	5.5 6.8	50.2	5.78 .36	5 7.7	74.7	6.12 .45	5.4 7.8	56.3

Notes: In the "MICRO_BA" and "MICRO_I" courses, the results correspond to all the academic periods available. Due to the lack of data availability on some students, groups in which a single student has GPA data or when the number of students without available data within the team is greater than 2 are excluded.