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Analyzing the impact of COVID-19 on the grades of university education: A case study with economics students

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ABSTRACT

COVID-19 has been one of the major incidents in the global university education system in recent years. Its influence and effects on education are still difficult to determine today. Both students and teachers have had to change their study and work routines and disciplines, in many cases lacking the necessary infrastructure to adapt to online learning. Students had to start a new academic year with a complete return to face-to-face teaching without having overcome, in many cases, the incidence of online learning. This study, through 167 responses to a survey addressed to economics students at the Universidad Politécnica de Madrid, aims to analyse the causes of an improvement or a worsening of the academic performance of university students in the return to normality after having gone through COVID-19's restrictions. The results obtained show that students, students who attend tutorials and those who have evaluated online teaching positively, are the ones who have most improved their performance in the return to face-to-face teaching. And those who have suffered the physical and psychological consequences of COVID and those with less infrastructure and income have worsened their results.

1. Introduction

Spain forced the closure of all universities and education centres on March 12, 2020. A few days later, on March 14, 2020, the State of Alarm was declared, and strict home confinement of the entire population was imposed, except for those related to essential services. The global pandemic of COVID-19, declared on 11 March 2020, was the cause of the radical change in education that students and teachers had to face (BOE, 2020; Camilleri, 2021; Díez-Gutiérrez & Gajardo-Espinoza, 2020).

The absence of students from the classrooms and the start of distance and online teaching affected the end of the academic year 2019/2020, and in most cases continued into the academic year 2020/2021. During this time, the universities and their teaching staff had to continue learning with the means at their disposal and in most cases without having gone through learning courses or adaptation of the subjects and content (Camilleri, 2021; Trujillo, 2020).

The lockdown and rapid transformation of educational activity had a severe impact on students and their learning process (Odrizola-González et al., 2020). Different studies have reported on the difficulties

and stress faced by students and teachers during this time of online teaching (Camilleri, 2021; Díez-Gutiérrez & Gajardo-Espinoza, 2020; Tejedor et al., 2020). The lack of social contact with peers and the difficulty of sharing knowledge and educational experiences profoundly altered university learning environments. In a similar vein, the difficulty of ensuring that all students have access to the same information under the same conditions became particularly evident (Bekerman & Rondanini, 2020). Some studies also suggest that the pressure on university students has been significant, but its effects have differed according to socioeconomic backgrounds (Odrizola-González et al., 2020). Students who did not have sufficient computer equipment, access networks or a non-shared room where they could receive telematic classes with the necessary privacy were the most affected by the confinement (Álvarez, 2020).

After the end of the state of alarm established by RD 463/2020, and the improvement of general parameters during the summer of 2020, the increase in cases made it necessary for the Government to declare a new state of alarm by means of RD 926/2020 dated October 25th, 2020, which was extended until May 8th, 2021 (Royal Decree-Law 8/2021, of 4 May). With the end of the state of alarm, which would hardly have any

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effect on the 20/21 academic year, and the improvement of the parameters related to the evolution of the pandemic, the plans for a return to face-to-face teaching in Spanish universities were slowly initiated. In the case of the Community of Madrid, on which the Universidad Politécnica de Madrid (UPM) depends, the academic year started on September 7th with a hybrid learning approach (online and face-to-face classes). The return to full face-to-face attendance took place only one month later, on October 4th, 2021.

Once again, there was a sudden shift to face-to-face learning and a mismatch between teaching programmed for online attendance and classroom attendance. As a result, teachers and students suffered a new setback caused by changes in teaching parameters and methods. In some cases, they returned to pre-confinement teaching, but in others they incorporated tools already used in the confinement period, which had to be modified to ensure distances and social collective security parameters (Aretio, 2021).

The cumulative impact of the COVID-19 pandemic on students' academic achievement has been large, but underexplored (Borgaonkar et al., 2021; Clark et al., 2021). This paper attempts to fill this gap by shedding light on how the COVID-19 pandemic has affected the academic performance of university students in the return to face-to-face learning. Based on a case study with economics students at the Universidad Politécnica de Madrid, the article analyses which factors have determined better and worse performance in students' grades.

This paper is articulated as follows: in section 2, the literature and hypotheses are studied; in section 3, materials and methods; in section 4, results; and finally, the discussion and conclusions are addressed in the last two points.

2. Literature review and hypotheses

The term 'academic performance' is often debated due to its multi-dimensional nature. However, for operational reasons, it is generally accepted that the grades obtained in the subjects taken at university are the best indicator of students' academic performance (Araya-Pizarro & Avilés-Pizarro, 2020; Fernández-Mellizo & Constante-Amores, 2020; Mora-García, 2015; Tomás-Miquel et al., 2014).

Numerous studies have analyzed the factors that influence the academic performance (grades) of university students [e.g., 12-16-17]. These studies, carried out in more stable environments than those conditioned by the COVID-19 crisis, reveal a series of factors that may have an impact on the differential performance of students. Mora-García (Mora-García, 2015) distinguishes between psychosocial factors (personal characteristics of the student, motivation, anxiety, self-esteem, etc.) and socio-demographic factors (gender, family's economic level, employment situation, parents' level of education, etc.). Other authors [e.g., 12] consider demographic (gender and age), socio-economic (i.e., the socio-economic level of the family, which can have repercussions on having to combine work and school) and academic factors (access grade and type of school).

Although studies have been conducted by many authors, this problem is still insufficiently explored. Only few works have analyzed the impact of COVID-19 crisis on the grades of university students and their results are inconclusive (Karadag, 2021). For example, Clark et al. (Clark et al., 2021), found that students improved their grades during COVID-19 due to the use of online systems. On the contrary, Borgaonkar et al. (Borgaonkar et al., 2021), indicate a decline in performance, especially in first year engineering courses, because of a drop in class attendance and student motivation. It is necessary to comment on how an increase in the so-called "contract cheating" may have occurred during COVID-19, as this element has already been recognized in different studies [e.g. 19–21]. It is impossible to know the extent of this practice in the present study, although it is true that the students who were evaluated online signed a loyalty commitment before taking the tests. Although in this study, we focus on the return to face-to-face attendance when the possibility of cheating on exams became much

more restricted, but this element could be considered a limitation of the study.

More importantly, to our knowledge, no previous study has analyzed how returning to the classroom have affected the academic performance of university students. Thus, this research addresses the gap that exist in terms of how academic performance has evolved in post-confinement and what are the differential elements that have caused some students to see their grades improve or worsen when they returned to face-to-face learning. This research contributes to the literature on the impact of the COVID-19 pandemic on students' academic achievement and focuses on a little-studied period, the post-confinement. The study will serve as a basis for future research on the subject and will help education authorities to contextualize possible actions in the event of a pandemic.

In the analysis, we have assumed that the factors that affected students' performance during confinement continue to be decisive and have also influenced students' academic performance upon return to the classroom. One of these factors is the socio-economic level of the students, which has been extensively referenced in several studies (Aucejo et al., 2020; Betts & Morell, 1999; Cyrenne & Chan, 2012). These studies show that students with fewer resources have felt the impact of COVID-19 the most. Following Clark et al. (Clark et al., 2021), our study analyses the impact of appropriate study space and technology on academic achievement.

Hypothesis 1. Low economic status of students will influence students to have lower grades.

Other factor that is studied in this article is the student's perception on the adequacy of online teaching. Some authors indicate that certain elements used in online teaching (e.g., continuous tutoring and test-type evaluations instead of conventional exams) have contributed to improve the quality of learning and could be maintained in the return to face-to-face teaching (Aretio, 2021; Clark et al., 2021; Yu et al., 2022). Our hypothesis is that those students who have better adapted to online teaching tools may have a greater chance of improving or maintaining their performance.

Hypothesis 2. A positive adaptation of students to online learning will positively affect their grades.

In addition, the COVID period exposed students to stressful situations, in many cases due to an excessive workload that has hardly ever evaluated, nor has its influence on performance determined (Beena & Sony, 2022; Nguyen et al., 2020; Yu et al., 2022).

Hypothesis 3. Work overload experienced by students during COVID-19 will influence lower grades.

Thus, the physical, psycho-logical and emotional consequences of COVID-19 are key factors and have also included in our study. The most challenging aspect of learning during COVID-19 is the increase of reported cases of mental health issues in college students (Ibarra-Mejía et al., 2021; Khobragade et al., 2021; Tubbs, 2021).

Hypothesis 4. Those students who have suffered the physical and psycho-logical consequences of COVID-19 will obtain lower grades.

Finally, gender issues are examined. Here, two opposing effects must be considered. There is no consensus on the performance of men and women, while some argue that women get better grades (Betts & Morell, 1999; Richardson & Woodley, 2003), other studies have not reached these conclusions and equalize the performance of both genders (Alghamdi et al., 2020; Gestsdottir et al., 2021; Richardson & Woodley, 2003). On the other hand, COVID-19 has caused mental disorders and psychological problems for students due to stress and isolation, and these effects have been greater in women than in men (Balderas & Caballero-Hernández, 2020; Gestsdottir et al., 2021). Although men have a greater tendency to abuse drugs and alcohol during periods of stress such as that experienced with COVID-19 (Gestsdottir et al., 2021).

Hypothesis 5. Female students will obtain similar grades to their male counterparts in the return to face-to-face training.

3. Materials and methods

3.1. Sample

In order to obtain information on the performance of university students in the return to face-to-face teaching, an on-line survey was conducted for some economic courses at the Universidad Politécnica de Madrid, which we present as a case study. The participants are studying economic subjects taught by the Department of Agricultural Economics, Statistics and Business Management. The study was carried out between October and December 2021, and 167 grade students participated. The students were informed of the ethics statement of the study, ensuring the non-use of data on an individual basis, always aggregated and ensuring the confidentiality of their responses, with no traceability of their participation (see Appendix I).

The characteristics of the participants in the survey are summarized in Tables 1 and 2.

The average age is around 21 years old, with slightly more than two years at the university, with around 6 courses at a time, and with a slightly greater preponderance of men than women.

3.2. Variables

A research question is posed: How have student's grades (dependent variable) evolved in the return to face-to-face teaching, and to what of the factors considered in the hypotheses could have affected their performance, namely, socioeconomic level, evaluation of online teaching, workload, having suffered the physical or psychological consequences of COVID, and being a woman. On the other hand, some control variables (Benson & Brown, 2011) have been considered that can show other aspects not considered by the hypotheses, such as: attendance to tutorials before, during and on return, the realization of other activities outside the study, such as social actions before, during and on return, and written exams several authors have related tutorials and a better performance (Binani & Chowdary, 2018; Bunce et al., 2017; John, 2005; Kramer et al., 2018) and related with worst performance number of courses (Whitfield & Xie, 2002). Table 3 shows the variables used to test or reject the hypotheses.

Table 4 shows the descriptive statistics of the different variables, as well as their methodological definition. In Appendix I, the questionnaire and the questions that condition the different variables are shown, and the reference to previous studies that have been sources of the questionnaire used.

Table 5 shows the correlations between the different variables observed. Tau B of Kendall's has been calculated as they are non-parametric variables.

3.3. Regression model

To assess the relationship between the independent variables and the dependent variable, an ordered logit regression is proposed. The objective is to determine the relationship between the explanatory (independent) variables X_i and an ordinal response variable with g levels. The ordered logit model is derived from a latent variable model where Y^* is an unobserved variable that, in our case, may reflect latent student's perceptions on the impact of COVID in their academic performance and can be related to the set of independent variables X_i as

Table 1
Characteristics of the sample in terms of gender.

Variable	N responses	Percentage of total	
Gender	Female	77	46.1%
	Male	87	52.1%
	N/A	3	1.8%

Source: own elaboration.

Table 2

Characteristics of the sample in terms of age, years at the UPM and n° of courses taken.

Variable	N	Mean	Min	Max	Standard dev.
Age	167	20.4	18	42	3.16
Years in university	167	2.28	1	5	1.11
Number of courses	167	6.05	1	10	1.29

Source: own elaboration.

Table 3

Hypotheses and variables used to test.

Hypotheses	Variable (number)
H1: Low economic status of students will influence students to have lower grades.	Inadequate workplace (2), the workplace has not improved and was inadequate, see (Clark et al., 2021)
H2: A positive adaptation of students to online learning will positively affect their grades.	Online learning assessment (3)
H3: Work overload experienced by students during COVID-19 will influence lower grades.	Online workload (4)
H4: Those students who have suffered the physical and psycho-logical consequences of COVID-19 will obtain lower grades.	Physical and emotional consequences in COVID time (5) Physical and emotional consequences in recovery (6)
H5: Female students will obtain similar grades to their male counterparts in the return to face-to-face training.	Gender (7)
Control variables	Tutorial (8) Other Activities (9) Written exam (10) Number of courses (11)

Source: own elaboration.

expressed in equation (1).

$$Y^* = \sum_{i=1}^d \beta_i X_i + \varepsilon_i \tag{1}$$

Where β is the vector of parameters to be estimated, ε is the random disturbance following normal distribution, $\varepsilon \sim N(0,1)$.

While Y^* is unobserved, we can observe a response variable Y , in our case with 5 levels, and can define the following relationship between them. Let $\mu_1 < \mu_2 < \mu_3 < \mu_4$ be four unknown threshold or cut-off parameters, we assign five values to the observed response variable Y such that: $Y = 1$ if $Y^* \leq \mu_1$; $Y = 2$ if $\mu_1 < Y^* \leq \mu_2$; $Y = 3$ if $\mu_2 < Y^* \leq \mu_3$; $Y = 4$ if $\mu_3 < Y^* \leq \mu_4$; $Y = 5$ if $\mu_4 < Y^*$. The cumulative probability of a given variable Y is the probability that Y^* is less than or equal to a given value g (Harrell, 2001). Thus, taking into account that the dependent variable Y^* represents the probability that the student obtains worst, somewhat worst, neutral, somewhat better or better grades, the ordered logistic model is defined as follows:

$$Y^* = \text{logit} [P(Y \leq g | X)] = \sum_{i=1}^d \beta_i X_i + \varepsilon_i \tag{2a}$$

Where $g = 1, 2 \dots 5$ represents the five possible values taken by the observed dependent variable. In our case, the explanatory variables are the variables number (2) to (11) defined in Table 3, while the variable Y is the observed response variable (1) Grades, defined in five levels as shown in Table 3 ($g = 1, 2, \dots 5$). Substituting X for each of the independent variables, we have:

$$\text{logit} [P(Y \leq g | X)] = \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \beta_{10} X_{10i} + \varepsilon_i \tag{2b}$$

where the explanatory variables are Inadequate workplace (X_1), Online learning asses (X_2), Online workload(X_3), Physical and emotional consequences in COVID (X_4), Physical and emotional consequences in recovery (X_5), Gender(X_6), Tutorial(X_7), Other activities(X_8), Written

Table 4
Descriptive statistics of the variables used.

Variable	Definition	N	Mean	Std. Dev.	Min	Max
Grades (1)	Student grades in the return to face-to-face teaching. Where 1 is much worse, and 5 is much better (Question 10 see Appendix I).	163	2.51	1.085	1	5
Inadequate Workplace (2)	Dummy variable that takes the value 1 if the workplace has not improved and was inadequate, and 0 otherwise (Question 7e, see Appendix I).	166	0.05	0.215	0	1
Online learning assessment (3)	Assessment of online versus face-to-face learning. Where 1 is much lower, and 5 is much higher (Question 11, see Appendix I).	162	2.24	1.168	1	5
Online workload (4)	Assessment of the workload of online versus face-to-face teaching. Where 1 is much lower, and 5 is much higher (Question 12, see Appendix I).	161	3.55	1.024	1	5
Physical and emotional consequences in COVID time (5)	Assessment of the physical and emotional consequences generated by confinement. Where 1 is very low and 5 is very high (Question 5a, see Appendix I).	166	3.47	1.189	1	5
Physical and emotional consequences in recovery (6)	Assessment of the physical and emotional Covid consequences in recovery. Where 1 is very low and 5 is very high (Question 5b, see Appendix I).	164	3.19	1.138	1	5
Gender (7)	Dummy variable that takes the value 1 if the student is defined as female, and 0 if the student is defined as male (Question 1, see Appendix I).	164	(see Table 1)			
Tutorial (8)	Frequency with which the student has had tutorials before, during confinement and on return to face-to-face attendance. Where 1 is very low frequency, and 5 is very high frequency, for each period (Question 9 see Appendix I , sum of 9a, 9b and 9c).	163	7.26	2.705	2	15
Other Activities (9)	Work, volunteering, or elderly care activities that the student has combined before, during and upon returning to the classroom (Question 6 see Appendix I , sum of 6a, 6b and 6c).	167	1.24	1.652	0	9
Written exam (10)	Student assessment of written exams as main evaluation tool (Question 8, sum of the written exam, see Appendix I)	167	2.24	0.830	0	3
Number of courses (11)	Number of courses the student has enrolled in (Question 4, see Appendix I).	166	6.05	1.290	1	10

Source: own elaboration.

exam (X_9), Number of courses (X_{10}), and ε is the random disturbance following normal distribution, $\varepsilon \sim N(0,1)$.

4. Results

[Table 6](#) shows the development of the ordered logistic regression model.

The effects of the independent variables have been tested to ensure that they are the same depending on the level of the dependent variable, with the test of the parallel regression assumption, which is shown in [Table 6](#), allowing the ordered logistic regression model used in [Table 7](#) to be validated.

The results show that the probability of obtaining an improvement in the grades of university students in the return to face-to-face teaching is positively influenced by the positive evaluation of online learning assessment ($P > z = 0.017$ and Coef = 0.3369), the student's attendance to tutorials ($P > z = 0.040$ and Coef = 0.1211). With less significance, by being a woman ($P > z = 0.160$, out of the 95% of confident interval but inside the 80%, with a Coef of 0.4473) and other activities ($P > z = 0.192$, out of the 95% of confident interval but inside the 80%, with a Coef. of 0.1269). In addition, the factors that reduce the likelihood of performance improvement and cause lower performance are the physical and emotional consequences in COVID ($P > z = 0.000$ and Coef = -0.6586), the physical and emotional consequences in recovery ($P > z = 0.010$ and Coef = -0.35), inadequate workplace arrangements ($P > z = 0.022$ and Coef = -1.685), taking a greater number of subjects ($P > z = 0.019$ and Coef = -0.2815). Regarding the hypotheses put forward in this work, the results show the following conclusions: [Hypothesis 1](#) is confirmed since having an inadequate workplace, linked to belonging to lower income groups ([Cyrenne & Chan, 2012](#)), is related with worst performance. [Hypothesis 2](#) on the adaptation and valuation of online teaching and its relationship with the improvement in grades is confirmed. [Hypothesis 3](#), on the negative effect of the workload during COVID-19 on grades, is rejected. [Hypothesis 4](#), on the negative effects of the physical and psychological effects of COVID-19 on grades, is confirmed. Finally, it is shown that the gender option does not have an influence on the grades, so [hypothesis 5](#) is confirmed, although a higher confidence range, 80%, would allow to defend a better perceived performance of women in the return to presence. In the [Fig. 1](#), we resume

the results of the study differentiating between negative and positive effects of the variables that have been found to be significant.

5. Discussion

The crisis of the COVID-19 pandemic has undoubtedly had a severe influence on teaching throughout the academic world, as various studies have corroborated [e.g. 2-3, 6, 9, among others]. These studies have reported adverse impacts related to the lockout of COVID-19, from the stress suffered by students, the lack of adaptation of schools and universities, the lack of knowledge of students and teachers of the technologies and methodologies to be implemented ([Asgari et al., 2021](#); [Bilen & Matros, 2021](#); [Camilleri, 2021](#); [Prowse et al., 2021](#)), as well as factors of loneliness, incomprehension and isolation of students and teachers ([Clark et al., 2021](#); [Rodríguez-Planas, 2022](#)).

Once the initial phase of COVID-19 had passed, there was a return to face-to-face teaching. However, this return to normality has been tinged with the ink of the previous period. This has been visualized through different elements ranging from, the maintenance of social distance, the use of the masks, the fear of physical contact and proximity ([Camilleri, 2021](#); [Ewing, 2021](#)) and also the maintenance of routines and procedures introduced in the confinement period, such as online teaching, the increased use of test exams or video conferencing ([Aretio, 2021](#); [Ewing, 2021](#); [Zhao & Watterston, 2021](#)).

Thus, students in the return to face-to-face learning are incorporated into an environment that is close to the previous one, but at the same time disconcerting and alien to them. Libraries are not used, classes become cold and extremely stuffy places with distant and distant teachers ([Camilleri, 2021](#); [Lockee, 2021](#)). This undoubtedly has an impact on the evolution of their performance, which is the gap that this article aims to fill. Since not all students are the same, and not all students have the same capacity for adaptation, what are the factors that facilitate students' improved performance in the return to face-to-face teaching and how has this been influenced by COVID-19?

We have analyzed the factors that have historically been related to student performance, such as gender, the number of subjects taken, and the socio-economic status (through the availability of a suitable workplace). In addition, other elements linked to the COVID-19 crisis have been incorporated into the study, such as the evaluation of online

Table 5
Tau B of Kendall's correlation matrix.

Tau B of Kendall	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Grades (1)	1.000										
Inadequate workplace (2)	-.170*	1.000									
Online learning asses. (3)	.166*	.050	1.000								
Online workload (4)	-.121	.063	-.114	1.000							
Physical and emotional conseq.in COVID (5)	-.279**	.067	-.266**	.195**	1.000						
Physical and emotional conseq. in recovery (6)	-.225**	.163*	.104	.003	.037	1.000					
Gender (7)	-.024	-.043	-.120	.068	.186**	-.029	1.000				
Tutorial (8)	.136*	.126	.088	.050	.064	-.049	.166*	1.000			
Other Activities (9)	.030	.055	.035	.063	-.042	.084	-.192**	.060	1.000		
Written exam (10)	-.072	-.088	-.025	.037	.039	.017	.105	.081	.019	1.000	
Number of courses (11)	-.048	.057	.095	.000	-.125	.057	-.232**	-.062	.029	-.165*	1.000

** . The correlation is significant at the 0.01 level (bilateral). * . The correlation is significant at the 0.05 level (bilateral).
Source: own elaboration

Table 6
Logistic regression model.

Grades	Coef,	Std, Err	z	P > z	[95% Conf, Interval]
Inadequate workplace	-1.6853	0.7364	-2.29	0.022	-3.1287 -0.2419
Online learning assessment	0.3369	0.1415	2.38	0.017	0.0594 0.6143
Online workload	-0.1719	0.1454	-1.18	0.237	-0.4570 0.1131
Physical and emotional consequences in COVID	-0.6586	0.1421	-4.63	0.000	-0.9370 -0.3801
Physical and emotional consequences in recovery	-0.3500	0.1364	-2.57	0.010	-0.6173 -0.0827
Gender	0.4473	0.3181	1.41	0.160	-0.1761 1.0707
Tutorial	0.1211	0.0589	2.06	0.040	0.0057 0.2365
Other Activities	0.1269	0.0973	1.30	0.192	-0.0639 0.3177
Written exam	-0.0836	0.1262	-0.66	0.507	-0.3309 0.1636
Num. of courses	-0.2815	0.1204	-2.34	0.019	-0.5176 -0.0455
/cut1	-5.6845	1.2796			-8.1925 -3.1765
/cut2	-3.8684	1.2378			-6.2945 -1.4423
/cut3	-1.8960	1.2177			-4.2827 0.4907
/cut4	-0.1063	1.2376			-2.5319 2.3193
Number of obs					165
LR chi2 (10)					59.60
Prob > chi2					0.0000
Log likelihood = -207.221					Pseudo R2 0.1257

Source: own elaboration.

Table 7
Test of the parallel regression assumption.

Test	Chi2	Df	P > Chi2
Wolfe Gould	31.91	30	0.372
Brant	16.22	30	0.981
Wald	15.69	30	0.985

Source: own elaboration.

teaching, the psychological and emotional effects of COVID-19, workload, and the provision of appropriate technology has become a key element in the monitoring of courses (Araya-Pizarro & Avilés-Pizarro, 2020; Lockee, 2021). With these variables affected by the COVID-19 pandemic and the direct changes undergone in the adaptation of university education, five working hypotheses have been formulated, and four control variables have been used (Benson & Brown, 2011).

Although previous studies have addressed similar problems under different contexts, the results are complex to relate because of their novelty. The results obtained show that the positive evaluation of online teaching is the factor that most affect the improvement of student grades. Thus, our hypothesis 2 (students who have better adapted to online teaching tools may have a greater chance of improving or maintaining their performance) is confirmed. Along these lines, studies show that online teaching is not a complete substitute for face-to-face teaching. Asgari et al., [408], reveal that half of the students reported feeling tired and demotivated by video-conferencing classes. Also indicate that in the most disadvantaged neighborhoods there is a greater decrease in attendance in online classes: Although the sentiment is not

unanimous, most students rate the online learning experience as positive and their rating increases in the year following the closure of the classrooms (Martín-Núñez et al., 2022). Along the same lines, we have found no correlation between inadequate work environment, a variable related to low family income, and negative evaluation of online learning (see Table 5). Online teaching has led to an improvement in students' grades over those who did not receive online teaching, and students who took exams using a computer also perform better than those who did not take exams using this technology (Clark et al., 2021).

Our study also demonstrates that the use of tutorials has contributed to improved grades. Previous studies have already noted the importance of class attendance and contact with the teacher, which was only possible through tutorials in the COVID-19 period (Araya-Pizarro & Avilés-Pizarro, 2020; Béjar & Vera, 2022). The abrupt shift to remote learning due to the COVID-19 pandemic caused teachers to look for new types of evaluation methods. In many cases, traditional written exams were replaced by alternative assessment methods (e.g., computer-based tests, paper reviews, etc.) that were well received by students (Bor-gaonkar et al., 2021; Clark et al., 2021; Sletten, 2021). García et al. (García et al., 2022) indicate that students improved their grades by using computer tools in parallel to the usual paper-based exam technology.

The results obtained suggest that the impact of COVID-19 persists after returning to face-to-face teaching. Students who have endured psychological and physical consequences during COVID-19 and who had poor working facilities and technology had difficulty recovering performance.

Several authors have shown that students with fewer resources have

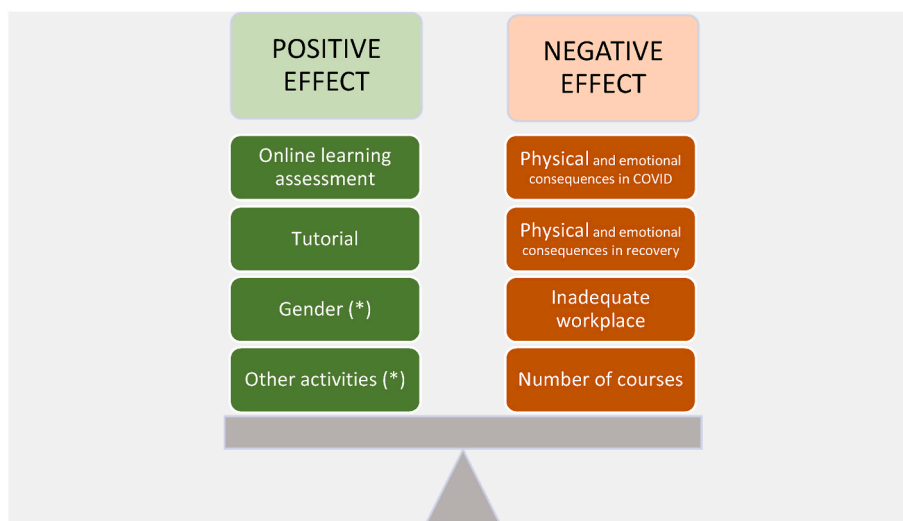


Fig. 1. Variables with an effect on student grades.

Source: own elaboration. (*) Only for confident interval of 80%

felt the impact of COVID-19 the most. Aucejo et al. (Aucejo et al., 2020) show that lower-income students are more likely to delay graduation than their higher-income peers because of COVID-19. Also, Rodríguez-Planas (Rodríguez-Planas, 2022) highlights how the gap between social classes in the classroom has increased during and after COVID, as it has been the neediest students, who had to work in order to combine studies and work or who have lost their jobs due to COVID, which has further reduced their resources. This relates to the widely discussed digital divide, that in many cases is related to lower socio-economic status (Zhao & Watterston, 2021). The results of this study support previous findings that inadequate workspace and technology lead to lower student performance (Abu Talib et al., 2021; Di Pietro et al., 2020). Other elements that worsen academic performance in the post-confinement COVID period are taking a high number of subjects and being an undergraduate student. The increased workload of taking more subjects at the same time and the reduced university experience of undergraduates has an impact on students' grades (Betts & Morell, 1999; Mora-García, 2015).

Finally, it is important to note that women have the perception of having improved their grades more than men in the return to face-to-face learning (80% of confident interval). Some studies revealed that women have suffered more than men the consequences of the COVID crisis and its psychological, emotional, and isolating effects (Prowse et al., 2021). Therefore, it is possible that the end of this stressful situation has brought about a kind of release and, as a result, an improvement in their performance. This is a possibility that the authors consider possible, but that further studies should corroborate.

6. Conclusions

This study reveals that the COVID-19 effect persists and has negatively affected students' results. Students who have more difficulty adapting to new circumstances, such as those encountered in COVID-19, have poorer academic results. The ability to adapt to the new circumstances caused by the COVID-19 epidemic or the ability to have more resources available to adapt appears as an important factor. This element had already been suggested in other studies but not in the COVID-19 pandemic, and this is undoubtedly the novelty of this study. And ability to adapt has been shown in this study through various elements, adapting better to online teaching (coef = 0.33 and $P > z = 0.017$), attending, and using tutorials (coef = 0.12 and $P > z = 0.04$), having broader horizons (carrying out other activities) (coef = 0.13 and $P > z = 0.19$), and the complex and little studied gender effect (coef = 0.45 and

$P > z = 0.16$). On the other hand, the lack of adaptation has specific causes, the COVID-19 disease condition (coef = -4.63 and $P > z = 0.00$), the availability of less financial means and taking more subjects than the average of the other students (coef = -0.28 and $P > z = 0.02$). Thus, not all social strata are equally affected by COVID in the return to face-to-face learning. Lower income strata of society have a worse performance in the return to face-to-face learning, and women improve their performance in the return to face-to-face learning, after having suffered more severely from the consequences of COVID. The technological gap appears as a key factor and becomes even more relevant as it highlights the importance of all students not having adequate equipment and environment to carry out their studies (coef = -1.68 and $P > z = 0.02$). This is especially important because the use of interactive technologies could become the norm, in a post COVID-19 era (Borgaonkar et al., 2021; Camilleri, 2021).

The positive conclusions of this study focus on the factors that favor better student performance in the return to face-to-face teaching, adapting to new circumstances and environments is therefore vital. These include the integration of communication technologies in teaching, the importance of students' use of tutorials, and the development of multiple-choice tests (Nallusamy & Punna Rao, 2018). This opens the door to the development of online teaching and courses, which will undoubtedly gain momentum after the COVID crisis (Aretio, 2021; Díez-Gutiérrez & Gajardo-Espinoza, 2020; Lockee, 2021). This study presents a series of limitations, derived from the type of research, a subjective survey, and the scope of the study. Thus, the possibility of lack of rigor in the responses may be a limitation on the data obtained. On the other hand, the survey was carried out in Spain and at the Universidad Politécnica de Madrid, for students of economics courses. It is difficult to extrapolate these analyses to other universities and other academic environments and this is undoubtedly a limitation that should be supported by further research.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

APPENDIX I. QUESTIONNAIRE (this questionnaire is based on and adapted from those carried out by UNESCO (iesalc) and the Universidad Pública de Navarra) UNESCO iesalc, 2021, Universidad Pública de Navarra

Confidentiality agreement

This survey is part of a teaching research project that aims to evaluate the return of students to face-to-face teaching. The survey is anonymous, and the data will only be treated in aggregate form, and your confidentiality will be protected. Thank you very much for your collaboration.

Question 1. Indicate if you are male or female

Question 2. What is your year of birth?

Question 3. How many years have you been at the Universidad Politécnica de Madrid?

Question 4. How many courses are you taking this semester?

Question 5. Do you consider that the possible physical and emotional consequences generated by the confinement (muscular and joint atrophy, eating problems, sleep disorders, anxiety, sadness ...).

- a) affected your performance in your studies during that period.
- b) How they affect you when you return to the classroom.

Scale from 1 to 5, where 1 is very little, 2 is little, 3 is neutral, 4 is quite a lot and 5 is a lot.

Question 6. What activities have you combined, or do you combine with your studies?

- a) before confinement
- b) during confinement
- c) during the return to presence

Please indicate any of the following three options, 1) work, 2) volunteering, 3) care for the elderly or minors.

Question 7. Regarding your workspace, equipment and internet access, please indicate if:

- a) It has improved during the confinement and this improvement has been maintained during the return to face-to-face
- b) Improved only during confinement
- c) Improved after return to face-to-face confinement
- d) No improvement, it was already adequate

- e) No improvement despite the fact that it was inadequate
- Question 8. Indicate the three evaluation systems that you BEST valued/value.
- a) before confinement
 - b) during confinement
 - c) during the return to presence

Please indicate any the following four options, 1) oral exam, 2) written exam, 3) multiple-choice exam.

Question 9. How often do you tutor or communicate with your teachers?

- a) before confinement
- b) during confinement
- c) during the return to presence

Scale from 1 to 5, where 1 is very little, 2 is little, 3 is neutral, 4 is quite a lot and 5 is a lot.

Question 10. How has the Covid situation affected your qualifications?

Scale from 1 to 5, where 1) are worse, 2) are somewhat worse, 3) are neutral, 4) are somewhat better, 5) are better.

Question 11. Compared to face-to-face teaching, I consider that with online teaching:

Scale from 1 to 5, where 1) I have learned much less, 2) I have learned less, 3) I have learned the same, 4) I have learned more, 5) I have learned much more.

Question 12. The workload due to online teaching has been:

Scale from 1 to 5, where 1) much lower than face-to-face, 2) lower than face-to-face, 3) similar to face-to-face, 4) higher than face-to-face, 5) much higher than face-to-face.

Question 13. How would you evaluate the use of these tools?

- Videoconferencing
- Digital presentations
- Written teaching materials
- Problem cases resolution
- Online resolution (webinars)
- Participation in forums etc.

Scale from 1 to 5, where 1) very bad, 2) bad, 3) neutral, 4) good, 5) very good.

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