Student Engagement and Academic Performance during the COVID-19 Pandemic: Does a Blended Learning Approach Matter?

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This paper examines whether and to what extent student engagement with the learning management system (LMS) Blackboard affects students' academic performance during the COVID-19 pandemic. We find strong evidence that higher student engagement with Blackboard is associated with better academic performance. We also find that the association between student engagement and student academic performance varies with different blended learning formats. Specifically, the positive effects are more pronounced when synchronous online lectures and face-to-face tutorials are implemented. Given that COVID-19 is a constantly moving situation, this study highlights that a blended learning approach needs to engage students actively to facilitate social interaction with teachers and peers during periods of social restrictions.

INTRODUCTION

The onset of the COVID-19 pandemic has led to fundamental change in almost all sectors of our society. Higher education is no exception. COVID-19 undermined traditional face-to-face teaching practices and forced the learning delivery mode to switch to online unpredictably and rapidly (Mishra et al., 2020; Maurer, 2022). Although prior literature suggests that academic continuity planning should be in place to deal with class cancellation associated with the threat of pandemics (Day, 2015), in the initial months of the COVID-19 pandemic, the lockdowns and containment measures imposed in most countries resulted in the hasty closure of university campuses and a clumsy transition to remote, off-campus delivery of all academic activities. Not surprisingly, almost every Australian university announced the immediate suspension of in-person classes and moved entire programs to fully online learning in the first semester of 2020. Because of its strict lockdowns and hard boarder restrictions, Western Australia (WA) was in a better position to mitigate the COVID outbreak than the other states in Australia. As such, in semester 2, 2020, WA universities started to reopen campuses partially. While large-scale lectures were still delivered fully online, blended learning course delivery was adopted for tutorials and laboratory sessions.

With the rapid development of learning technologies in the last two decades, non-traditional forms of teaching and learning such as blended learning are becoming increasingly popular in higher education (Navarro, 2015). 'Blended learning' is defined as a combination of face-to-face and online activities, incorporating asynchronous online and synchronous face-to-face/online activities (Bonk & Graham, 2012; Heilporn et al., 2021). The benefits of this approach may include facilitating flexible learning, optimizing student engagement, and improving self-regulated learning (see, for example, Finlay et al., 2022). However, we are aware of little empirical work examining whether and to what extent student participation and performance differ under different formats of blended learning course delivery amid the COVID-19 pandemic. To fill this gap in the literature, this paper attempts to shed light on the interrelationship between student engagement, academic performance, and blended learning in higher education during the COVID-19 pandemic.

Blended learning course delivery is not new for Australian university students. In normal times, whether students take online classes depends on their personal preferences and circumstances. In other words, students could self-select between face-to-face, online, or hybrid delivery modes. However, during the COVID-19 pandemic, the number of students enrolled in face-to-face classes has been capped owing to public health concerns. This "first come, first served" rule allocates or forces students to study online to some extent. In other words, online learning is not the students' choice, but they are obliged to partake in it. Hence, COVID-19 presents a unique opportunity to test the notion that blended learning approach matters for student engagement and performance.

To the best of our knowledge, no prior study has analyzed the effects of prescribed enrollment in online versus face-to-face classes on engagement and performance during COVID-19. The present study has profound implications for teaching and learning innovation in a post-COVID-19 world. For example, if the impact of student engagement on academic performance varies between students who have taken online versus face-to-face classes, it is worth exploring different teaching strategies to accommodate the two distinct delivery modes. Further, if one of these two student groups is disproportionately harmed from the emergency switch to blended learning, educational institutions and the government should offer these students additional psychological, emotional, and financial support.

The previous literature finds that student engagement is a major predictor of student success (Williams & Whiting, 2016; Talafuse, 2021). Fredricks et al. (2004) define "student engagement" as having three interrelated dimensions: behavioral, emotional, and cognitive. *Behavioral engagement* concerns student participation in activities, completion of given assessments, and compliance with attendance rules. *Emotional engagement* corresponds to the emotional reactions (positive/negative) to activities, classmates, and teachers, and students' sense of belonging to the course. *Cognitive engagement* refers to the psychological investments in activities to learn and master complex knowledge and skills.

This study focuses on student engagement with a learning management system (LMS). Williams and Whiting (2016) define an LMS as "an enterprise-wide and internet-based system that integrates a wide range of pedagogical and course administration tools" (p. 303) and find that LMSs can improve and increase the level of student engagement. Nkomo et al. (2021) assert that "most of the LMS actions, such as logging on, posting on forums, accessing learning resources, and assignments, are behavioral trait and would mostly favor the behavioral dimension" (p. 14). Although prior literature suggests that LMSs can allow various forms of synchronous and asynchronous modes of engagement to happen and have the potential to support student involvement and enrich the learning experience (Klobas & McGill, 2010; Williams & Whiting, 2016), it remains unclear whether student engagement with the Blackboard LMS leads to better learning outcomes (Sclater, 2008).

More specifically, this study explores two research questions (RQs):

RQ1—Did student engagement with the Blackboard LMS affect academic performance?

RQ2—To what extent did the effects of student engagement with the Blackboard LMS on academic performance vary by blended learning course delivery format?

DATA, VARIABLES, AND SAMPLE

Student participation and performance data were collected from a second-year undergraduate course (Introductory Business Financial Modelling) in the second semester of 2020 at one of the largest public universities in WA. The data were retrieved from Blackboard Analytics. The LMS Blackboard is the key tool to engage students and enhance learning in an "emergency remote teaching and learning" environment at the institution,[1] and the LMS reports and tracks student activities through tools such as Blackboard Analytics. Blackboard was already embedded into the university's business as usual mode pre-pandemic. However, prior to pandemic, Blackboard is used for instructors to upload course material (e.g., lecture notes and pre-recorded iLectures), rather than deliver synchronous classes. Discussion Board and Blackboard Collaborate are the main Blackboard tools used in this course to interact/engage with students during the pandemic semester. In Discussion Board, students can share thoughts and ideas about class materials; pose questions about homework, readings, and course content; and meet with their peers for collaboration on group assignments. Both synchronous online lectures and computer labs are delivered via Blackboard Collaborate, which is a real-time video conferencing tool that allows instructors add to files, share application/screen, and use a virtual whiteboard to interact. Although Blackboard Collaborate is a very interactive platform, students' experience of joining a virtual session may not be the same as the experience of attending a face-to-face classroom venue, in particular, for computer labs involving substantial hand-on or applied activities.

Student involvement with the LMS is measured by "Unit Accesses"—the number of times students accessed the Blackboard site (*unitaccesses*) and "Interactions"—the number of clicks or page views in the Blackboard site (*unitinteractions*). Academic performance is proxied by the scores of assessments completed by students. There are three assessments for this course: a lab test (*test*), a financial analysis project (*project*), and a final assignment (*assignment*). Both the individual assessment score and total score (*mark*) are considered in this study. During the pandemic semester, the way *test* and *assignment* were administered was changed from invigilated closed-book exams to open-book take-home online assessments.

The course is composed of a one-hour lecture and two-hour computer laboratory weekly. There were 210 students taking this course in semester 2, 2020 (August 3, 2020–November 27, 2020). As mentioned in the Introduction, blended learning approaches allow synchronous activities to happen online instead of face-to-face, thanks to the considerable improvement of digital technologies (Lakhal et al., 2017; Lakhal & Bélisle, 2020). To comply with the social-distancing rules, synchronous online lectures were delivered to accommodate the 210 participants. Four synchronous computer labs were taught face-to-face to 126 students, and two synchronous computer labs were provided online to 84 students. Computer labs provide students with hands-on learning experience, opportunities for peer-to-peer collaboration, and exposure to the practical aspects of the financial industry. Social restriction would inevitably affect such applied activity. The course largely remained the same across both computer-lab delivery modes in terms of learning materials, content, and assessment.

We also control for student background information, including age (age); gender (gender); course (course); major (major); academic year level (year); academic standing (stand); failed attempts (failedattempts); non-native English speaker status (esl); location—urban, regional, or remote area (urban); basis for admission (admn); and first child in family (first). Key student characteristics data shows that the average age of the student cohort is 22 years old, and male students dominate the sample (77%). In addition, 31% of students in our sample are from non-English speaking backgrounds, and the majority of students (62%) are from urban areas.[2] We also observe that 55% of students in the sample are first child in family. Table 1 presents summary statistics for the variables. Figure 1 shows the average of students' activity in this unit, i.e., Unit Accesses (unitaccesses), Unit Interactions (unitinteractions), and Unit Minutes (unitminutes) each week against the average for their activity in their other units in the same year and study period. As shown, students' activity in this unit closely moves with their activity in the other units. In addition, the Figure indicates that there is a sharply increase in students' activity in Weeks 8, 11, and 16. This is perhaps because three assessments for this unit are conducted in these three weeks. Hence students are more likely to engage with Blackboard site. The definitions and abbreviations used for all variables are contained in Appendix 1.

EMPIRICAL MODEL AND RESULTS

To investigate the effects of student engagement with the LMS on academic performance, we estimate the following ordinary least squares (OLS) regression models, summarized by Equations 1 and 2:[3]

$$Score_i = \alpha_1 + \beta_1 Engagement_i + \gamma_1 Controls_i + \varepsilon_i \quad (1)$$

$$Score_i = \alpha_1 + \theta_1 Engagement_i \times f2f + \gamma_1 Controls_i + \varepsilon_i \quad (2)$$

where *i* indexes the student. The dependent variable, *Score*, is one of four assessment scores; that is, individual score (*test*, *project*, and *assignment*) and overall score (*mark*). The key independent variable, *Engagement*, is student engagement with the Blackboard LMS, proxied by *unitaccesses* or *unitinteractions*. A binary variable (*f2f*) is used to indicate whether a student enrolled in online or face-to-face labs. It takes the value of 1 if the student enrolled in face-to-face labs and 0 otherwise. We include student demographic characteristics (*Controls*) to capture student background

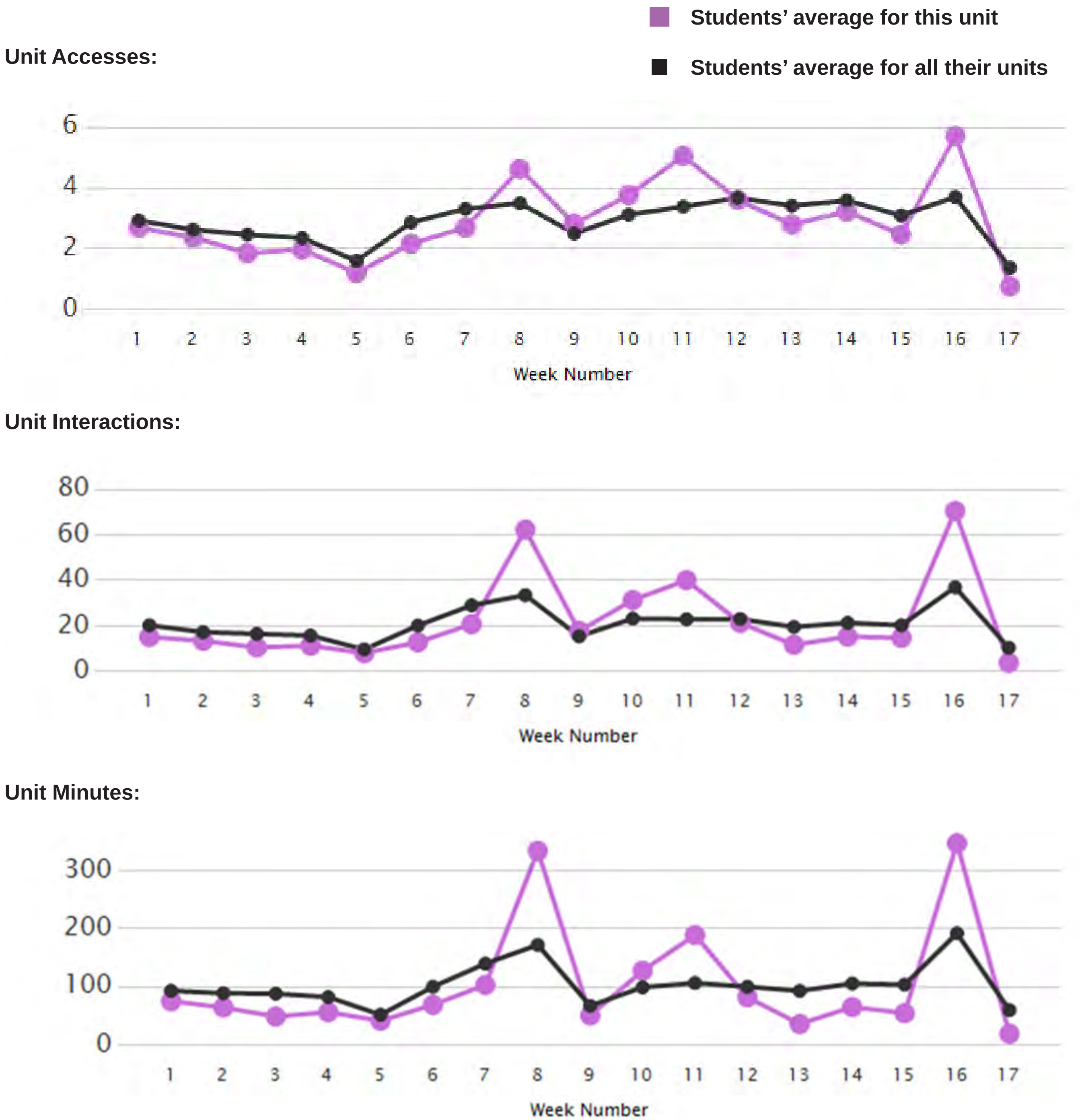

Figure 1. Unit Activity over Time

This Figure shows the average of students’ activity in this unit — Introductory Business Financial Modelling, each week against the average for their activity in their other units in the same year and study period (Source: Blackboard Analytic data).

Table 1. Summary statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	***N***	**mean**	***p50***	***sd***	**min**	**max**	***p25***	***p75***
test	210.000	15.024	16.500	4.416	0.000	20.000	13.000	18.500
project	210.000	24.313	25.350	4.057	0.000	29.850	21.750	27.150
assignment	210.000	38.883	40.500	7.662	12.500	49.500	34.500	44.500
mark	210.000	78.220	81.450	13.026	28.150	97.650	70.500	87.500
unitaccesses	210.000	50.986	40.000	66.150	14.000	927.000	31.000	56.000
unitinteractions	210.000	391.414	302.000	518.375	88.000	7,156.000	231.000	412.000
age	210.000	21.957	22.000	2.197	19.000	32.000	20.000	23.000
gender	210.000	0.771	1.000	0.421	0.000	1.000	1.000	1.000
course	210.000	1.524	1.000	1.187	1.000	8.000	1.000	1.000
major	210.000	22.691	24.500	9.040	1.000	35.000	17.000	32.000
year	210.000	1.333	1.000	0.492	1.000	3.000	1.000	2.000
stand	210.000	1.100	1.000	0.301	1.000	2.000	1.000	1.000
failedattempts	210.000	0.081	0.000	0.290	0.000	2.000	0.000	0.000
esl	210.000	0.310	0.000	0.463	0.000	1.000	0.000	1.000
urban	210.000	2.005	1.000	1.371	1.000	4.000	1.000	4.000
admn	210.000	4.500	5.000	0.903	1.000	5.000	4.000	5.000
first	210.000	0.548	1.000	0.499	0.000	1.000	0.000	1.000

Note: This table reports summary statistics for key variables used in the regression estimates. See Appendix 1 for variable definitions. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2. The effects of student engagement with the Blackboard LMS on academic performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**test**	**test**	**project**	**project**	**assignment**	**assignment**	**mark**	**mark**
unitaccesses	0.005		0.007*		0.016***		0.028**	
	(0.004)		(0.004)		(0.005)		(0.011)	
unitinteractions		0.001		0.001*		0.002***		0.003**
		(0.000)		(0.000)		(0.001)		(0.001)
age	0.260**	0.265**	0.312***	0.318***	0.301	0.313	0.873***	0.897***
	(0.102)	(0.102)	(0.103)	(0.104)	(0.220)	(0.218)	(0.326)	(0.325)
gender	1.274*	1.262*	-0.265	-0.281	-0.956	-0.992	0.054	-0.011
	(0.729)	(0.730)	(0.764)	(0.764)	(1.041)	(1.041)	(1.919)	(1.920)
course	0.472**	0.477**	0.285	0.291	-0.576	-0.558	0.181	0.210
	(0.232)	(0.234)	(0.247)	(0.247)	(0.565)	(0.564)	(0.894)	(0.895)
major	-0.001	-0.001	-0.000	0.000	0.065	0.067	0.064	0.066
	(0.037)	(0.037)	(0.033)	(0.033)	(0.062)	(0.062)	(0.111)	(0.111)
year	0.748	0.742	0.482	0.451	1.766*	1.759*	2.996*	2.952*
	(0.593)	(0.592)	(0.536)	(0.538)	(1.005)	(1.009)	(1.609)	(1.615)
stand	-0.896	-0.889	-2.028*	-1.972*	-0.616	-0.616	-3.540	-3.477
	(1.148)	(1.145)	(1.045)	(1.044)	(1.746)	(1.747)	(2.863)	(2.850)
failedattempts	-3.156***	-3.165***	-3.061*	-3.086*	-8.745***	-8.766***	-14.962***	-15.017***
	(1.144)	(1.142)	(1.733)	(1.739)	(2.275)	(2.264)	(4.038)	(4.034)
esl	-0.846	-0.875	-1.213*	-1.279*	0.399	0.328	-1.660	-1.826
	(1.038)	(1.034)	(0.710)	(0.709)	(1.322)	(1.327)	(2.367)	(2.373)
urban	-0.157	-0.145	-0.185	-0.153	-1.261**	-1.234**	-1.603*	-1.533
	(0.389)	(0.387)	(0.276)	(0.277)	(0.550)	(0.551)	(0.947)	(0.949)
admn	0.053	0.064	-0.345	-0.328	-0.486	-0.455	-0.779	-0.719
	(0.384)	(0.386)	(0.254)	(0.255)	(0.592)	(0.594)	(1.015)	(1.023)
first	-1.000	-1.002	0.085	0.090	-1.205	-1.217	-2.121	-2.129
	(0.682)	(0.680)	(0.663)	(0.665)	(1.157)	(1.158)	(1.939)	(1.940)
Constant	8.487**	8.327**	20.969***	20.741***	35.896***	35.437***	65.352***	64.506***
	(3.569)	(3.583)	(3.099)	(3.095)	(6.042)	(6.032)	(9.942)	(9.977)
Observations	210	210	210	210	210	210	210	210
R-squared	0.134	0.134	0.138	0.134	0.164	0.164	0.184	0.183

Note: This table presents the regression estimates analysing Equation 1 on the relationship between student engagement with Blackboard and academic performance during the COVID-19 pandemic. unitaccesses and unitinteractions are two measures of student engagement; test, project, assignment, and mark are proxies for a student's assessment score. Robust standard errors are reported in parentheses. The variable descriptions are in Appendix 1. *, **, and *** represent significance at the 10%, 5% and 1% level, respectively.

Table 3. The effects of student engagement with the Blackboard LMS on academic performance under different formats of blended learning course delivery

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**test**	**test**	**project**	**project**	**assignment**	**assignment**	**mark**	**mark**
unitaccesses	0.003		0.005**		0.012***		0.020***	
	(0.002)		(0.002)		(0.003)		(0.005)	
unitinteractions		0.000		0.001**		0.001***		0.002***
		(0.000)		(0.000)		(0.000)		(0.001)
f2f	-0.825	-0.792	-0.499	-0.019	-1.729	-1.574	-3.053	-2.385
	(0.928)	(0.917)	(0.964)	(0.825)	(1.520)	(1.476)	(2.708)	(2.556)
unitaccesses × f2f	0.028**		0.024*		0.040**		0.093***	
	(0.012)		(0.014)		(0.018)		(0.033)	
unitinteractions × f2f		0.004**		0.002		0.005**		0.010***
		(0.002)		(0.001)		(0.002)		(0.004)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	210	210	210	210	210	210	210	210
R-squared	0.153	0.156	0.158	0.147	0.174	0.176	0.207	0.204

Note: This table reports the regression estimates analysing Equation 2 on the relationship between student engagement with Blackboard and academic performance during the COVID-19 pandemic. unitaccesses and unitinteractions are two measures of student engagement; test, project, assignment, and mark are proxies for a student's assessment score. A binary variable (f2f) is used to indicate whether a student has enrolled in online labs or face-to-face labs. It takes the value of 1 if the student enrolled in face-to-face labs and 0 otherwise. Students' demographic control variables are included in all specifications (not shown for brevity). Robust standard errors are reported in parentheses. The variable descriptions are in Appendix 1. *, **, and *** represent significance at the 10%, 5% and 1% level, respectively.

information other than engagement with the LMS that may potentially affect assessment score—that is, *age*, *gender*, *course*, *major*, *year*, *stand*, *failedattempts*, *esl*, *urban*, *admn*, and *first*.

Table 2 presents the regression results for Equation 1. As can be seen, the coefficients on *Engagement* are positive and statistically significant in three of four academic performance measures. These results suggest that higher student engagement with the LMS is associated with a higher assessment score during the pandemic, after controlling for a host of student demographic variables. We also find that older students are more likely to achieve higher scores, whereas previously failed students are less likely to achieve higher scores. Table 3 reports the results for Equation 2. Consistent with our main results in Table 2, the coefficients on student engagement (*unitaccesses* and *unitinteractions*) are positive and statistically significant in most specifications, indicating that students with higher engagement with the LMS tend to perform better in their assessments. More important, the coefficients on our key variables of interest, the interaction terms of *unitaccesses* × *f2f* and *unitinteractions* × *f2f*, are large, positive, and statistically significant. Our findings support that the effects of student engagement with the LMS on academic performance may vary across different types of blended learning course delivery. Specifically, the positive impact is found for students who enrolled in face-to-face labs rather than synchronous online labs.

CONTROLLING FOR ENDOGENEITY

Thus far, we have documented a significant positive relation between student engagement with the Blackboard LMS and academic performance. A potential endogeneity issue may cloud the interpretation of the causal relation between student participation in learning delivered via an LMS and assessment score. Endogeneity arises when the dependent variables and explanatory variables being examined affect one another. The main sources of endogeneity concern are omitted variable bias, self-selection bias, reverse causality. Omitted variable bias concerns arise if variables are missing from analysis. Self-selection bias is a type of sampling error excluding certain observations e.g., in the case of this study, only students with the Blackboard interaction are selected. Reverse causality occurs if the dependent variable influences the explanatory variable, i.e., instead of student engagement with the Blackboard LMS impacting academic performance, student performance impacts the classified level of interaction with the Blackboard site. The endogenously determined behaviours may lead to statistical bias in the estimated parameters, thereby rendering invalid any conclusions drawn from simple multivariate regressions. In this section, we employ an instrumental variable (IV) or a two-stage least squares (2SLS) to address these concerns and further validate the interpretation of our results.

We identify "*unitminutes*," an estimate of the student's time spent in the Blackboard site, based on their access or interaction, as our instrumental variable. Identification of the IV model requires a strong correlation between the instrument and endogenous variable (the relevance criterion), and that the instrument must be valid in the sense that it should not affect the dependent variable except through the endogenous variable (the exclusion criterion). It is reasonable to expect the "*unitminutes*" to be highly related to "*unitaccesses*" and "*unitinteractions*." It is logically impossible that "*unitminutes*" should directly affect assessment score, except through its relation with "*unitaccesses*" and "*unitinteractions*."

Based on this discussion, in the first stage of IV regressions, we regress *Engagement* on the instrumental variable, along with a set of student demographic variables, as specified in Equation 1. The first-stage estimation model can be written as Equation 3:

$$\widehat{Engagement}_i = \alpha_0 + \beta_1 unitminutes_i + \delta_1 Controls_i + \varepsilon_i \quad (3)$$

where $\widehat{Engagement}_i$ is the predicted/fitted value of one of our two main engagement measures, "*unitaccesses*" and "*unitinteractions*." "*unitminutes*" is the instrument for our endogenous engagement variable, measuring a student's time spent in the Blackboard site. Student demographic controls are defined as in Equation 1. In the second stage, we regress *Score* on the predicted/fitted value of *Engagement* from the first-stage estimation and all controls. The second-stage regression is formally expressed as Equation 4:

$$Score_i = \alpha_0 + \beta_{\widehat{engage}} \widehat{Engagement}_i + \delta_1 Controls_i + \varepsilon_i \quad (4)$$

Table 4. Endogeneity test – Instrumental variables approach										
Panel A: f2f = 1	**First stage**		**Second stage**							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Variables	**unit accesses**	**unit interactions**	**test**	**test**	**project**	**project**	**assignment**	**assignment**	**mark**	**mark**
unitminutes	0.016***	0.157***								
	(0.003)	(0.022)								
fitted unitaccesses			**0.067*** **		**0.041** **		**0.058***		**0.167*** **	
			(0.023)		(0.019)		(0.032)		(0.057)	
fitted unitinteractions				**0.007*** **		**0.004** **		**0.006***		**0.017*** **
				(0.002)		(0.002)		(0.003)		(0.006)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	126	126	126	126	126	126	126	126	126	126
R-squared	0.577	0.723	0.163	0.198	0.189	0.174	0.239	0.246	0.272	0.282
First stage F-statistic (strength of instruments)	30.83***	49.13***								
Panel B: f2f = 0	**First stage**		**Second stage**							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Variables	**unit accesses**	**unit interactions**	**test**	**test**	**project**	**project**	**assignment**	**assignment**	**mark**	**mark**
unitminutes	0.038***	0.302***								
	(0.011)	(0.082)								
fitted unitaccesses			**-0.001**		**0.008**		**0.011**		**0.019**	
			(0.005)		(0.005)		(0.007)		(0.012)	
fitted unitinteractions				**-0.000**		**0.001**		**0.001**		**0.002**
				(0.001)		(0.001)		(0.001)		(0.001)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	84	84	84	84	84	84	84	84	84	84
R-squared	0.718	0.721	0.225	0.225	0.147	0.146	0.202	0.202	0.197	0.195
First stage F-statistic (strength of instruments)	12.71***	13.68***								

Note: This table shows instrumental variable (IV) regression estimates of student engagement with Blackboard on academic performance during the COVID-19 pandemic to address concerns of endogeneity (see, Equations 3 and 4). unitaccesses and unitinteractions are two measures of student engagement; test, project, assignment, and mark are proxies for a student's assessment score. A binary variable (*f2f*) is used to indicate whether a student has enrolled in online labs or face-to-face labs. It takes the value of 1 if the student enrolled in face-to-face labs and 0 otherwise. The first stage regresses student engagement (unitaccesses and unitinteractions) on the instrumental variable (unitminutes), and all control variables as specified in the baseline model. The second stage regresses a student's assessment score (test, project, assignment, and mark) on the fitted/predicted value of student engagement variables (fitted unitaccesses and fitted unitinteractions) based on the estimates obtained from the first-stage regression, and a full set of control variables. For brevity, only estimates for fitted student engagement and instrumental variable are reported in this table. Robust standard errors are reported in parentheses. The variable descriptions are in Appendix 1. *, **, and *** represent significance at the 10%, 5% and 1% level, respectively.

where the dependent variable, *Score*, is one of four assessment scores; that is, *test*, *project*, *assignment*, and *mark*. The rest of the variables are defined as in Equation 1.

We split the sample into two subsamples—students who enrolled in face-to-face labs (*f2f* = 1) in Panel A and students who enrolled in online labs (*f2f* = 0) in Panel B. Results from the 2SLS regressions are presented in Table 4. In Columns 1 and 2, we report the coefficient estimates from the first-stage regression. Coefficients on the instrumental variable are statistically significant. Not surprisingly, the coefficient estimates for *unitminutes* are positively related to both measures of student engagement, *unitaccesses* and *unitinteractions*, satisfying the relevance criterion. The first-stage *F*-statistic of excluded instruments exceeds the cut-off value as proposed by Stock and Yogo (2005), indicating that the instrument is relevant and does not suffer from weak instrument concerns. The results from the second-stage regressions, with assessment scores (*test*, *project*, and *assignment*, *mark*) as the dependent variable, and the predicted/fitted value of engagement, *fitted unitaccesses* and *fitted unitinteractions*, as the key independent variable of interest, are presented in Columns 3–10. In Panel A, the positive and statistically significant coefficients of *fitted unitaccesses* and *fitted unitinteractions* confirm our earlier results that for students who are enrolled in face-to-face computer labs, higher student engagement with the Blackboard LMS leads to better academic performance, easing concerns of endogeneity bias. Panel B shows that the coefficients on student engagement, *fitted unitaccesses* and *fitted unitinteractions*, are insignificant, indicating that for students who are enrolled in synchronous online computer labs, their engagement with the Blackboard LMS is not related to academic performance. The sign and significance of the control variables are generally in line with the main findings (not shown for brevity).

CONCLUSION

This study aimed to investigate whether and to what extent student engagement with one LMS, Blackboard, influences students' academic performance during the COVID-19 pandemic, when a blended approach of face-to-face and online learning was implemented in an undergraduate business financial modeling course. The results of this study show that LMS usage and interaction have an overall positive impact on academic performance.

Further analysis suggests that the positive effects are more pronounced when a combination of synchronous online lecture and face-to-face computer labs is implemented.

Business financial modeling is a particularly applied course in which practical computer labs and assessments have been severely affected by COVID-19 social-restriction rules. This study suggests that students may have experienced poorer social interaction with online learning than with face-to-face interaction with peers and teaching staff. As such, students may need some degree of face-to-face or direct contact with teachers and peers to sufficiently grasp the required contextual knowledge, despite the strict social-distancing measures in place. The findings are in line with the notion that education is a social practice, and successful learning is facilitated by consistent social interaction (Laffey et al., 2006). Supporting this view, Brown and Liedholm (2002) and Alpert et al. (2016) examined face-to-face, online and hybrid learning models and found that students who learn purely online perform worst relative to students who learn via other formats.

There are some limitations to using Blackboard or LMS data to measure student engagement/participation in a course. As mentioned previously, engagement with an LMS is predominantly behavioral, so may not capture the emotional and cognitive dimensions of student engagement. Further, measuring clickstream data can be an inaccurate reflection of engagement. For example, the number of clicks or page views in the Blackboard site may not represent the same engagement as posting a discussion on a discussion board.

Future research should investigate students' voices/opinions regarding engagement in a course during the pandemic. Furthermore, student perceptions of the impact of COVID-19 on their current and future outcomes, such as academic performance, educational opportunities, labor market participation, etc. is a fruitful topic for future research. In addition to blended learning approach, financial and health shocks resulting from COVID-19 need to be considered in future study, as the psychological, emotional, and physical factors may also have affected students' academic performance. A caring teacher should understand their students' personal contexts and respond to individual students' needs (Walker & Gleaves, 2016). Due to the sudden shift to online learning, there is tremendous stress, anxiety, loneliness, pressure, and burnout in students. Exploring new strategies through which we can better support our students in an emergency remote teaching and learning environment is an important area of future work. Although the findings of this study are limited to a single course at one higher education institution, they could be used to inform and enhance future pedagogical approaches and assist in designing learning material for more applied business courses during periods of social restriction. Moving forward, this study implies that a blended learning approach needs to engage students actively to facilitate social interaction with teachers and peers to optimize students' learning and academic experience. Lastly, the study is carried out at one country in a particular cultural and philosophical environment. A cross-country investigation of student engagement and academic performance during COVID-19 would be a worthwhile direction for further research. and we plan to do so in our future work.

NOTES

1. See Calonge et al. (2022) for a comprehensive literature review of Strengths, Weaknesses, Opportunities, and Threats (SWOT) for students, faculties and institutions in an emergency remote teaching and learning environment during COVID-19.
2. Geographic location may have little impact on students' online experience. With the rapid development of technology, students located in regional and remote WA have consistent access to the computers and high-speed internet connection nowadays.
3. Statistical software STATA is used to conduct empirical analyses in this study.

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APPENDIX 1

DEFINITION OF VARIABLES

Variable	Definition
Panel A: Student engagement with the Blackboard LMS and academic performance variables	
unitaccesses	The number of times students accessed the Blackboard site
unitinteractions	The number of clicks or page views in the Blackboard site
test	A student's score on "lab test". The weight of this assessment is 20%
project	A student's score on "financial analysis project". The weight of this assessment is 30%
assignment	A student's score on "final assignment". The weight of this assessment is 50%
mark	A student's overall score in this unit. It is the sum of the score on *test*, *project*, and *assignment*
Panel B: Student demographic variables	
age	A student's age
gender	A student's gender (M=1; F=0)
course	A student's enrolled course (Bachelor of Commerce=1; Bachelor of Engineering=2, Bachelor of Laws=3, Bachelor of Science=4, Bachelor of Arts=5, Bachelor of Business Administration=6, Bachelor of Science=7, Not For Degree - Australian Credit Transfer=8)
major	A student's major – 35 indicators covering for example, accounting, economics, finance, engineering, data science, and etc. (not shown for brevity)
year	A student's academic year level (1st academic year=1, 2nd academic year=2, 3rd academic year=3)
stand	A student's academic standing (Good standing=1, Conditional=2)
failedattempts	Number of times a student failed in the unit
esl	Non-native English speaker status (Yes=1, No=0)
urban	A student's geographic area (Urban=1, Regional=2, Remote=3, Not Applicable=4)
admn	Basis for Admission (Complete Year 12 at School=1, Complete Higher Education Course=2, Special Entry not Mature Age=3, Other Basis=4, Unknown=5)
first	First child in family (Yes=1, No=0)