The Impact of Online Testing Mode on Business Assessment Test Performance Before and During COVID

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We examined the impact of the COVID-19 on a Southern California public university's the Business Assessment Test (BAT) scores. The analysis analyzed over 4,000 observations from Spring 2017 to Spring 2022. Results demonstrated a significant performance improvement during COVID, with the average BAT score increasing from 51.35 to 55.47. Furthermore, demographic factors like major, ethnicity, enrollment, gender, and English proficiency also influenced BAT scores. Finally, interaction effects, especially for quantitative test questions were significant between COVID and cs major, work, and language. The study provides insights for educators and policymakers regarding the implementation of online assessment format in the future.

Keywords: online testing, COVID, Business Assessment Test, gender gap, ethnicity gap

INTRODUCTION

The National Center for Educational Statistics survey showed only 25% of the college students enrolled in at least one online course in 2014, comparing to 75% of online enrollment in 2020 (Inside Higher Ed June 2022). Although the number online course offerings has increased in recent years, many colleges and universities are not adequately prepared to swiftly transition from traditional face-to-face instruction and testing modalities to online formats during the pandemic. This is due in part to the fact that online education was often perceived as auxiliary service rather than a mainstream educational paradigm. Also, institutional inertia has impeded the agile integration of online platforms. Consequently, the unexpected COVID emergency in March 2020 exposed the fragility of the digital capacities and the fragmentation of tech support across the higher education system. The logistical challenges of seamless transition to virtual learning and testing have become increasingly urgent. Such need and urgency call for research on online instruction and testing modalities.

This study aims to share our experience of implementing online assessment format of Business Assessment Test (BAT) during pandemic and further comparing the learners' BAT results when

transitioning in-person assessment format to online assessment format at one public university in Southern California. We analyze 4,413 observations of students' BAT scores from Spring 2017 to Spring 2022, covering both pre-COVID and during COVID periods. BAT assessments are administered in the capstone course - the final required course for graduation, offered to all undergraduate students at the College of Business. As such, student BAT scores are designated as the undergraduate business program Exit Assessment and are part of the portfolio of assessment tools used to comply with the Association to Advance Collegiate Schools of Business (AACSB) Accreditation Standard #5: Assurance of Leaning. In addition, we investigate whether certain learner demographics such as major, gender, language or ethnicity can explain the variations in BAT performance. Finally, we explore the impact of COVID on such main effects.

Our focus on these learner demographics is motivated by the prevalent gender and ethnicity gaps in higher education. Decades of inequity have been deeply rooted in every facet of higher education, with minoritized students often underperform their white and affluent counterparts in terms of course completion and graduation rates (Carnevale and Strohol, 2013; Perna and Finney, 2014; Witham et al., 2015). The COVID disruption can potentially exacerbate the performance gap across subpopulation of students. While many prior studies have documented how higher education institutions, faculty and students adapted to new normal of "virtual learning" environments (Adedoyin and Soykan, 2020; Barber, 2021; Brown et. al., 2021; Chen et. al., 2021; Chen et. al., 2022), few studies have explored the impact of COVID on the connection between learners' demographics and their assessment results. Thus, our study aims to examine BAT outcomes through the lens of diversity and inclusion. The findings of learners' exit performance throughout the pandemic era will enable us to better fine-tune online assessment tool. Furthermore, the detailed analytical results are expected to shed light on the deficiencies of learners' mastery in certain subjects which better guide us to design the "closing-the-loop" pedagogy.

The remainder of the paper is structured in four sections. In Section 2, we provide background information for the BAT. In Section 3, we review prior literature related to online assessment integrity and outcomes, especially on recent studies on the effect of COVID. Based on such literature review, the hypotheses on impact of COVID are developed. We then report our empirical findings and interpret such findings in Section 4. Finally, we conclude with suggestions for higher education institutions in Section 5.

BUSINESS ASSESSMENT TEST (BAT)

Business Assessment Test (BAT) was first implemented in Fall 2004 to assess leaners' competencies in business functional knowledge and quantitative skills. Since then, fifteen California State University campuses, five non-California higher education institutions and one international higher education institution have participated in BAT. Specifically, this test evaluates learners' performance on ten business related subjects: accountancy, economics, finance, information system, management, marketing, statistics, international business, ethics, and supply chain management. There are 10 multiple-choice questions covering each of the first 7 subjects. For the last 3 subjects of internal business, ethics and supply chain management, there are 5 questions covering each subject. Therefore, there are altogether 85 questions in the test. Questions in the test cover the fundamental knowledge that students are expected to retain after obtaining undergraduate business education. The test duration is set for 75 minutes, with students with learning disabilities or special need receiving accommodation. The test duration is purposefully set low to provide time pressure and keep students engaged the entire session. To perform well on the test, students need both speed and accuracy. As stated above, the test is administered every semester to incoming graduating seniors as an exit assessment of the business program. The test results are compared both with historical data and with those of peer universities. Before COVID, the data presented in this study is on par with those collected from other universities.

At the college, BAT was mainly administered in in-person testing environment before the outbreak of COVID. Each semester, the Office of Accreditation of the College of Business (COB) coordinates the testing dates and time with the undergraduate capstone course instructors. The custom-made ParScore scantrons were used to collect and analyze students' answers. The Office of Accreditation then shares the

BAT assessment results with Department Chairs. Afterwards, each department holds curriculum review meetings to solicit feedback and suggestions from faculty members. When the local heath authority imposed lockdown to fight for the rising COVID cases in the spring of 2020, the COB immediately transitioned BAT to online testing modality. Qualtrics – a flexible survey tool which is integrated with university secure single-sign-on, is selected to administer BAT. To maintain the integrity of the online process, the questions are randomized each time the link is accessed through Qualtrics. Test time is kept at the same 75 minutes after students finish the registration and demographic survey. Although the BAT is not anonymous, students are assured that the results do not impact their course grades or affect their graduation status. The test results are used collectively to gauge the quality of the business program. From the beginning of the semester, students are informed about BAT and its objectives. As a result, there is minimal incentive for students to cheat. To encourage high performance, certificates are awarded to those who score 80% or above.

LITERATURE REVIEW

Online Assessment Integrity

Assessment is a pivotal component of teaching and learning, characterized by key attributes such as validity, authenticity, reliability, equity, and transparency. Assessment outcomes empower faculty to revise their pedagogical approaches to deliver high-quality educational experience and achieve the expected learning outcomes. When assessment is conducted in an online environment, the assessment goals and attributes remain the same. However, ensuring assessment integrity becomes more imperative in online environments due to the lack of direct, in-person monitoring. While instructors can immediately address concerns during face-to-face testing, online assessments are often perceived as being more vulnerable to academic dishonesty. In their survey, King et al. (2009) report that among the sampled students, 73.6% believed that cheating is more feasible in an online course than a traditional one. Un-proctored online tests tend to inflate performance (Alessio et al., 2018) and are more vulnerable to academic misconduct (Fask et al., 2014; Harmon and Lambrinos, 2008; and Beck, V., 2014). In light of these findings, it is likely that such misconduct might intensify in the context of COVID. With all courses being delivered online, students may find more opportunities to engage in "cheating or consulting" activities using resources like web searches, Discord, Chegg, etc.

However, other research demonstrates that online testing can be a promising alternative to in-person one (Prisacari et al., 2017; Elkins et al., 2016). Comparing student performance in online and paper-based tests in a general chemistry course, Prisacari et al. (2017) report minimal difference between the two testing modes. The benefits of e-testing, including higher student achievement and favorable staff perception are also demonstrated by College of Medicine, Qassim University KSA during COVID pandemic (Elzainy, Sadik and Abdulmonem, 2020). In our study, the BAT performance of students has no bearing on their course grades or graduation status. Since students are informed in advance that the test does not affect their course grades or academic standing, and test results will be aggregated to assess the business program quality, they have minimal incentive to cheat. Furthermore, BAT questions are randomized, and the test period is kept short to limit the chance of academic dishonesty. With such a system in place, we don't expect that student BAT performance will be affected by online testing integrity.

Online Learning Outcomes

In addition to concerns over integrity of online assessment, prior students have also examined whether students perform differently in classroom environment versus virtual learning settings. Earlier studies before COVID (Bettinger et. al., 2017; Cosgrove and Olitsdy, 2015; Krieg and Henson, 2016) find that online learners perform worse than their peers who participate in traditional face-to-face instruction. Such subpar performances are attributed to the distraction caused by technology use during virtual learning, the lack of engagement with instructors and peers, the need for self-discipline, or the design deficiencies in online platform (Patterson and Patterson, 2017; Bettinger et. al., 2016; Figlio et. al., 2013; Bettinger et. al., 2017.) In contrast, other studies show that the students perform equally well in business courses regardless of whether they enroll in online courses or live classrooms (Arbaguh et al., 2009; Xu and Jaggars, 2013).

Noticeably, the attrition rate of students enrolled in online courses is far lower than that of leaners enrolled in traditional face-to-face courses (Alpert et al., 2016; Bettinger et al., 2017; Fendler et al., 2011). Presumably those who self-select into an online course are likely to feel confident or at ease with learning online, are also motivated and self-disciplined enough to do well.

Studies of student performance during COVID also report mixed results. For example, Engelhardt et al. (2020) find little impact of the COVID shutdown on students' learning outcomes as evaluated by either course grades or standardized assessment test results in undergraduate economics course. After examining the learning outcomes of over 10,000 students, they report that the student course grades are higher in the COVID-affected semester provided Drop, Fail and Withdraw rate remains steady. In contrast, Orlov et al. (2020) report that students perform much worse in spring 2020, in comparison to fall 2019, by examining end of term knowledge assessment results of seven economic courses. In addition, Prowse et al. (2021) also show that more than a third of students report the transitioning to online learning as difficult or very difficult, and COVID increase their mental stress level. Students' coping mechanism through the use of media, sleep, food or substance generally is not effective.

In this study, most graduating seniors have previously completed business core courses that encompass the content of BAT questions before the onset of COVID. These business core courses are usually taken in the first two years of a student's college career. This suggests that even those students graduating amidst the COVID have taken these foundational business courses before COVID. Notably, before the pandemic, less than 3% of full-time-equivalent students experienced online learning. Given the fact that most students have acquired knowledge of BAT questions in traditional face-to-face education, we surmise that transitioning to online testing and teaching driven by COVID has minimal impact on BAT results. Hence, we expect:

Hypothesis 1: Students' BAT performance during COVID is no worse than that of before COVID semesters.

Major, Gender and Ethnicity Effects

Besides BAT, the Major Field Test in Business (MFT-B) has also been adopted by numerous business schools as an assessment tool to evaluate learning outcomes across different business disciplines. Prior research has identified a performance advantage for accounting and finance majors on the MFT-B (Allen and Bycio, 1997; Bycio and Allen, 2007; Bielinska-Kwapisz and Brown, 2013; Settlage & Settlage, 2011; Suh, 2014; Word & Rook, 2012; Fairchild and Hahn, 2020). For example, Allen and Bycio (1997) discover that students majoring in accounting achieve significantly higher scores on the MFT-B compared to management and marketing majors. Bycio and Allen (2007) further demonstrate that finance majors perform significantly better than marketing and management majors. Similarly, Bielinska-Kwapisz and Brown (2013) find that management and marketing students score lower on the MFT-B when compared to accounting and finance students after controlling for standard variables such as ACT, GPA, and gender. Additionally, Suh (2014) indicates that being an accounting, economics, or finance major is associated with better MFT-B performance. The findings from Fairchild and Hahn (2020) also support the consistent higher achievement of accounting and finance majors compared to students from other majors on the MFT-B. Based on these prior findings, we group students of Accounting, Economics, Finance, Information Systems, and Supply Chain Management majors as the Quantitative majors; and those of General Business, Human Resources Management, International Business, Management, and Marketing as the Qualitative Majors. We predict that Quantitative majors will outperform Qualitative majors in BAT test.

Several studies on gender effects have consistently shown a male advantage in performance on the MFT-B. Bielinska-Kwapisz, Brown, and Semenik (2012) report a 4.33-point higher score for men compared to women after accounting for ACT scores, GPA, and extra credit incentives. Bielinska-Kwapisz and Brown (2013) also confirm men's MFT-B scores are significantly higher than women's scores after controlling for ACT and GPA. Similarly, Mason et al. (2011) find a 4.9-point advantage for males while controlling for GPA, SAT, age, transfer status, race, and major. Bagamery, Lasik, and Nixon (2005) observe an 8-point difference in male scores on the MFT-B using similar covariates. Other studies by Black and Duhon (2003), Bean and Bernardi (2002), Contreras et al. (2011), Mirchandani, Lynch, and Hamilton

(2001) and Settlage and Settlage (2011) also confirm that men outperform women on the MFT-B while considering standard covariates and dispositional factors. Given such consistent findings, we predict that in our data sample male students will outperform females.

The research on the impact of ethnicity on business test performance such as MFT-B or BAT is scarce. However, prior studies on how ethnicity influences other measures of academic performance in business undergraduate programs can be extrapolated. Many studies have documented that certain ethnic groups, such as African and Hispanic American students, may face more challenges and have lower academic performance, such as overall GPA, compared to White or Asian students in undergraduate programs. Factors such as socioeconomic background, access to resources, and cultural differences may contribute to these disparities (e.g., Eimers and Pike, 1997; Dolan, 2008; Rhodd, Schrouder and Allen 2009). For instance, Rhodd et al. (2009) show that ethnicity has significantly affected the overall academic success of undergraduate business majors. Their results demonstrate that African and Hispanic American students in the business program have lower course grades compared to their White counterparts, while Asian American students perform on par with their White counterparts. To explore the effect of ethnicity, we predict that students from well-represented ethnicities, such as White and Asian, will outperform their under-represented counterparts, such as African, Hispanic and Native Americans.

Hence, we summarize our Hypothesis 2 as follows:

Hypothesis 2: *Well-known effects of students' major, gender and ethnicity on BAT performance persist for the entire testing period.*

- Quantitative majors perform better on BAT than Qualitative majors.
- Male students perform better on BAT than female students.
- Students from well-represented ethnicities perform better on BAT than those from under-represented ethnicities.

Online Learning Outcomes and Learners' Attributes

There is an abundance of evidence suggesting that COVID has a negative impact on women's economic opportunities and mental health (Alon et al., 2020; Graeber et al., 2021; Etheridge and Spantig, 2020; Zamarro and Prados, 2021). However, less research has been conducted on gender inequality in education during the pandemic. Pandemic may have unevenly affected students' performance based on gender. On one hand, Prowse et al. (2021) show that a greater of proportion of female students self-report the transitioning to online learning as difficult and COVID negatively impact their course work, comparing to male students. Females are also more likely to report the negative impacts of COVID on their mental distress. Furthermore, COVID brought a new movement of teaching based on information and communications technology (ICT). Previous research has shown a well noted gender gap in ICT aptitudes and use, with women notably feeling less comfortable in ICT (Meelissen and Drent 2008).

On the other hand, a few studies suggest that the effects of COVID on student performance may not have uniformly favored men over women. De Paola et al. (2022), for example, find a negative effect of the pandemic on the number of course credits earned, but report no significant gender differences based on administrative data from a university in Southern Italy. Casalone et al. (2021) investigate the pandemic's effect on passing exams in three universities in Italy, Turkey, and Sweden. They observe that while the pandemic decreases the exam passing rates, lockdown policies somewhat mitigate this impact as students spend less time on outdoor activities. Bratti and Lippo (2022) conduct a study on the impact of the COVID on the academic performance of Italian university students, with a focus of gender difference. Their findings suggest that the pandemic does not widen the existing gender gap in student progression in terms of number of credits earned. In fact, women in certain college majors, such as social sciences and humanities, outperform men with respect to their GPA. Engelhardt et al. (2021) examine student performance in introductory microeconomics, macroeconomics, and statistics courses at a regional state university during COVID compared to previous three unaffected semesters. Their results indicate that women perform better than men in the COVID-affected semester.

Based on the mixed findings from prior studies, we propose the following hypothesis:

Hypothesis 3: *The gender gap in BAT performance during COVID is no larger than that of before COVID semesters.*

Students of under-represented ethnicities are facing unique challenges during the COVID. Students of Black, Latinx, Native American, and Pacific Islander communities may be at higher risk of contracting the virus and experiencing the illness or loss of a loved one. Preliminary data suggest that these challenges can exacerbate existing mental health issues and stress among these students (Lederer et al. 2021). Such students can experience numerous disruptions to their schooling, work, and living situations due to the pandemic, which may further hinder their academic progress, access to internships, and employment opportunities.

Meeta Kumar, director of student counseling at the University of Chicago, discusses the impact of pandemic-related stressors on students during a virtual Harvard forum. She highlights that while "all students are struggling with pandemic-related stressors such as isolation and fatigue, there are additional variables that impact mental health of [people of] color and marginalized communities." Kumar observes a broad range of mental health concerns including amplified stress, anxiety, depression, and trauma. In the survey on the impact of the COVID on college students from communities of color, Molock and Parchem (2022) report that the pandemic has a pervasive and harmful effect on the educational experiences and mental well-being of the students. This study also shows that many students experience mental health challenges and instances of racial discrimination, which could aggravate the negative impact of the pandemic on minority students.

Despite concerns about the unequal impact of the pandemic on different student subgroups, studies have shown no measurable effect on minority subgroups. For instance, Engelhardt et al. (2021) identify no measurable effect minority subgroup. Orlov et al. (2021) also use standardized end-of-course knowledge assessments to examine student learning during the COVID pandemic and find no evidence that minority student learning outcomes are more negatively affected than others. In another study, Engelhardt et al. (2023) investigate the impact of COVID on three different learning outcomes of undergraduate business students. They examine student final course grades, performance on standardized course-specific assessment tests, and the likelihood of dropping or withdrawing from a course or earning a grade of Fail. There are no statistically significant differences by race, indicating that the pandemic does not have a differential impact on minority students' learning outcomes.

Therefore, we predict:

Hypothesis 4: *The ethnicity gap in BAT performance during COVID is no larger than that of before COVID semesters.*

EMPIRICAL RESULTS AND INTERPRETATION

Descriptive Statistics and Trend

In this study, we analyze data from the Business Assessment Test (BAT) taken by graduating seniors in business majors at a large public university from spring 2017 to spring 2022. We also collect student Major, Ethnicity, Enrollment status (full time or part-time), Work (hours of employment per week), Gender, Age group, Language (native language), and Transfer status (whether they are transferred from community colleges)[1]. The BAT contains 10 multiple-choice questions each from Accounting, Economics, Finance, Management, Management Information Systems, Marketing, Statistics, and 5 multiple-choice questions each from International Business, Ethics and Supply Chain Management, resulting in a total of 85 questions.

After eliminating observations with missing data, we have 4,547 observations. We further exclude all observations with BAT score below 30 out of 85 (34%) since we believe such low performance doesn't reflect students' actual knowledge retention and is likely due to lack of serious effort. Overall, 2.9% of observations are excluded resulting in 4,413 valid observations. We first present student demographics in Table 1. Students of single Qualitative majors total 44.3% of the population; single Quantitative majors

total 51.8%; there are 3.9% of students of double or more majors. Female students total 46.6%; Male students total 53.4%. Students with under-represented ethnicities, African and Hispanic background, consist 41.2%; while students with other ethnicities consist 58.8%. With respect to other demographics, majority of students are transferred from community colleges (62.1%); full-time enrolled (70.1%), English preferred (76.7%), and of age group 20-25 (77.9%). Most students are employed while attending school. We then present student BAT performance by semester in Figure 1 where the long bar represents the average of questions answered correctly (Total) and the short bar represents standard deviation. We also report the number of students participating in each semester. The data covers 11 semesters from spring 2017 to spring 2022, with the pandemic began in the spring of 2020. Upon initial examination, we notice an improvement in student Total BAT performance during COVID, starting fall 2020. At the same time, we also notice an increase in the standard deviation of Total, indicating that alongside performance improvement during COVID, there is more diversity in student performance. We conduct statistical analysis in hypotheses testing later.

FIGURE 1
STUDENT TOTAL BAT AVERAGE PERFORMANCE BY SEMESTER - SPRING 2017 TO SPRING 2022 (N=4,413)
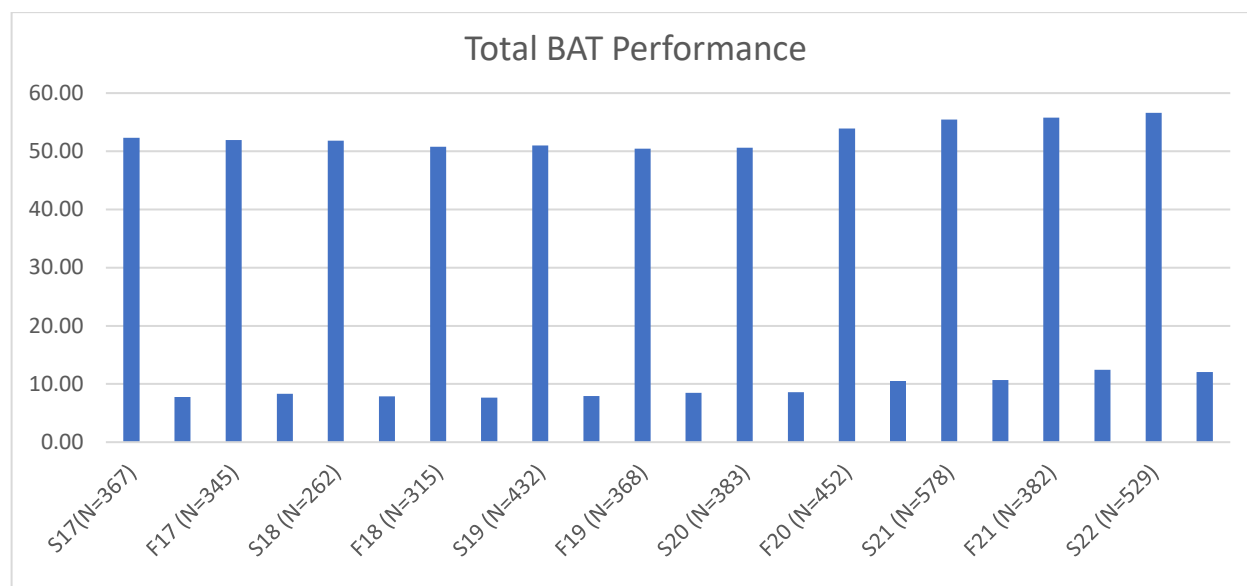
Long bar: Average number of questions answered correctly in BAT;
Short bar: Standard deviation of number of questions answered correctly.

TABLE 1
DESCRIPTIVES OF STUDENT DEMOGRAPHICS (N=4,413)

Major	Qualitative	Quantitative	Double		
	44.30%	51.80%	3.90%		
Gender	Female	Male			
	46.60%	53.40%			
Ethnicity	Underrepresented	Other			
	41.20%	58.80%			
Transfer	Transfer student	Non-transfer			
	62.10%	37.90%			

Enrollment	Part-time	Full-time			
	29.90%	70.10%			
Language	English preferred	Bilingual	Non-English preferred		
	76.70%	17.00%	6.30%		
Age	20-25	26-30	31-35	36-40	above 40
	77.90%	15.00%	4.10%	1.70%	1.30%
Work	0-10 hr	11-20 hr	21-30 hr	31-40 hr	above 40 hr
	27.90%	23.60%	28.20%	13.50%	6.70%

Given spring 2020 is the transition period with partly face to face instruction, we exclude this semester (N=383) in testing for impact of Covid. Data from spring 2017 to fall of 2019 are treated as before COVID (Covid=0; N=2,089), while data from fall 2020 to spring of 2022 are treated as during COVID (Covid=1; N=1,941)[2]. Next, we conduct correlation analysis of all demographic variables, Covid and Total BAT performance. The correlation results are presented in Table 2. Noticeably, Covid dummy is significantly correlated with Total BAT performance (r= 0.206; sig<0.01). As expected, Total BAT performance is significantly correlated with many demographic variables such as Major, Gender, and Ethnicity.

We also notice significant correlations between Covid and many demographic variables, suggesting a demographic shift in students before and during COVID. To further explore the trend, we conduct independent sample t-test with Covid dummy as the independent variable. Using Major, Ethnicity, Enrollment, Work, Gender, Age, Language and Transfer as the dependent variable separately, the simple t-test results for Covid are presented in Table 3, along with Levene's test results for equal variances. Based on the Levene's test results, the eight demographic variables' error variances during Covid are not the same as before. Based on the t-statistic and p-value when equal variances are not assumed, all of the above trends observed in correlation analysis are statistically significant. In other words, while the student body are not different in terms of weekly employment hours or gender composition during COVID comparing to before, the students are more likely to be from under-represented races, part-timely enrolled, older, native English speakers, and transferred from community colleges. Such an observation is in line with both anecdotal evidence and recent trends in undergraduate education (Cleveland-Innes, 2020; Espinosa et al., 2019). Finally, the significant impact of Covid on Major results from an increase in double major students, from 2.06% before COVID to 5.98% during COVID. Once double major students (N=159) are excluded from analysis, the effect of Covid on Major is no longer significant, meaning the composition of quantitative vs. qualitative major students doesn't change during COVID from before. These findings suggest that the demographic trend in our testing periods is likely to be representative of higher education in general.

TABLE 2
BIVARIATE CORRELATION BETWEEN DEMOGRAPHIC VARIABLES, SEMESTER, AND STUDENT BAT PERFORMANCE.
(N=4,030)

Pearson Correlation	Ethnicity	Enrollment	Work	Gender	Age	Language	Transfer	Semester	Covid	Total[a]
Major	.050**	-.036*	-0.005	-.121**	.065**	.045**	-0.021	0.006	.048**	.175**
Ethnicity		.042**	-.158**	-0.008	-.048**	0.019	.045**	-.081**	-.078**	.089**
Enrollment			-.035*	-0.005	-.109**	-0.019	.118**	-.288**	-.440**	-.054**
Work				-0.015	.168**	-.060**	-.081**	0.006	0.008	-0.020
Gender					0.011	.103**	.070**	-0.003	0.003	-.126**
Age						.088**	-.324**	.060**	.080**	.053**
Language							-.038*	-.045**	-0.028	-.048**
Transfer								-.078**	-.101**	-0.012
Semester									.894**	.181**
Covid										.206**

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed)

a. Total refers to the total number of questions answered correctly in BAT.

TABLE 3
T-TESTS OF DEMOGRAPHIC VARIABLES BEFORE AND DURING COVID (N=4,030)

		Levene's Test		T tests for equality of means					
		F	Sig.	t	df	Significance			Mean Diff.
						One-Sided p	Two-Sided p		
Major	Equal var. assumed	22.650	0.000	3.075	4028	0.001	0.002		0.055
	Equal var. not assumed			3.064	3903.188	0.001	0.002		0.055
Ethnicity	Equal var. assumed	84.166	0.000	-4.997	4028	0.000	0.000		-0.077
	Equal var. not assumed			-4.992	3985.968	0.000	0.000		-0.077
Enrollment	Equal var. assumed	2828.722	0.000	-31.068	4028	0.000	0.000		-0.407
	Equal var. not assumed			-30.588	3246.228	0.000	0.000		-0.407
Work	Equal var. assumed	10.348	0.001	0.535	4028	0.296	0.593		0.021
	Equal var. not assumed			0.534	3961.231	0.297	0.594		0.021
Gender	Equal var. assumed	0.140	0.709	0.187	4028	0.426	0.851		0.003
	Equal var. not assumed			0.187	4006.098	0.426	0.851		0.003
Age	Equal var. assumed	74.347	0.000	5.106	4028	0.000	0.000		0.121
	Equal var. not assumed			5.068	3739.974	0.000	0.000		0.121
Language	Equal var. assumed	13.426	0.000	-1.783	4028	0.037	0.075		-0.033
	Equal var. not assumed			-1.787	4028.000	0.037	0.074		-0.033
Transfer	Equal var. assumed	152.658	0.000	-6.471	4028	0.000	0.000		-0.099
	Equal var. not assumed			-6.483	4025.917	0.000	0.000		-0.099

Testing of Hypotheses 1 and 2

We then conduct analysis to test Hypotheses1: the impact of Covid on student Total BAT performance. The means and standard deviation of Total scores and scores by each subject are presented in Table 4. The average of Total in the ten semesters tested is 53.33 out of 85 questions, or 62.7%. The average BAT score during COVID (55.47) is higher than that of before (51.35), indicating a positive change in performance. We perform univariate ANOVA with Total as the dependent variable, Covid and all demographic variables as the independent variables, including interaction terms between Covid and each demographic variable. We present the means of Total by various demographic variables in Table 5, and ANOVA between subject test results in Table 6. Compared to before COVID, student Total BAT performance improved during COVID (F=17.158, Sig.<0.001). Therefore, Hypothesis 1 is supported. Our findings are consistent with some prior studies, as they suggest that students perform equally well in business courses regardless of whether they enroll online or in live classrooms (Arbaguh et al., 2009; Xu and Jaggars, 2013).

TABLE 4
DESCRIPTIVE STATISTICS OF BAT PERFORMANCE IN TOTAL AND BY EACH SUBJECT

Covid		Total (85)	ACCT (10)	ECON (10)	FIN (10)	MGMT (10)	MIS (10)	MKTG (10)	STAT (10)	INTL (5)	ETHICS (5)	SCM (5)
Before (N=2,089)	Avg	51.35	6.38	5.21	6.59	5.76	4.55	6.60	5.10	3.51	4.37	3.27
	Std.	8.04	1.81	1.82	1.92	1.40	1.73	1.50	1.90	1.08	0.97	1.03
	%	60.4%	63.8%	52.1%	65.9%	57.6%	45.5%	66.0%	51.0%	70.2%	87.3%	65.4%
During (N=1,941)	Avg	55.47	6.89	5.80	6.74	6.38	5.43	7.25	5.42	3.75	4.35	3.47
	Std.	11.41	1.92	2.07	2.04	1.82	1.96	1.91	1.90	1.07	0.97	1.07
	%	65.3%	68.9%	58.0%	67.4%	63.8%	54.3%	72.5%	54.2%	75.0%	86.9%	69.3%
Total (N= 4,030)	Avg	53.33	6.63	5.50	6.67	6.06	4.97	6.91	5.26	3.63	4.36	3.36
	Std.	10.02	1.88	1.97	1.98	1.65	1.90	1.74	1.91	1.08	0.97	1.06
	%	62.7%	66.3%	55.0%	66.7%	60.6%	49.7%	69.1%	52.6%	72.5%	87.1%	67.3%

TABLE 5
TOTAL BAT PERFORMANCE BY MAJOR, GENDER, ETHNICITY AND OTHER DEMOGRAPHIC VARIABLES

		Mean	N	Std. Deviation
Major	1-Qual Major	51.31	1787	9.818
	2-Quan Major	54.89	2084	9.835
	3-Double Major	55.66	159	10.628
Gender	1-Male	54.51	2153	9.873
	2-Female	51.98	1877	10.027
Ethnicity	1-Under represented	52.25	1643	9.901
	2-Other	54.07	2387	10.041
Enrollment	1-Part-time	54.15	1249	10.380
	2-Full-time	52.97	2781	9.838
Transfer	1-Transfer	53.43	2491	10.335
	2-Nontransfer	53.18	1539	9.498
Language	1-English preferred	53.60	3082	9.776
	2-Bilingual	52.59	690	10.449
	3-NonEnglish preferred	52.14	258	11.516
Age	1- 20 to 25	53.01	3127	9.801
	2- 26 to 30	54.20	613	10.690
	3- 31 to 35	55.03	169	10.370
	4- 36-40	56.63	68	11.324
	5- over 40	52.49	53	10.564

Next, we also observe main effects of Major, Ethnicity and Gender on student Total BAT performance as predicted in Hypothesis 2. In addition, we also report the main effects of Enrollment, Age and Transfer. These results are listed below.

- Major. We group students of the following majors together as Qual Majors (Major =1): General Business, Management, Marketing and International Business. We also group students of the rest business majors such as Accounting, Economics, Finance, Management Information Systems, and Supply Chain Management, as Quan Majors (Major =2). Students graduating with more than 1 major are grouped as Double Majors (Major=3). Qual Majors score on average 51.31 for Total, while Quan Majors score 54.89 and Double Majors score 55.66. Such difference is statistically significant, F= 52.07, Sig.<0.001, indicating Quan and Double Majors perform better than Qual Majors in Total BAT test.
- Gender. Male students (Gender =1) score better than Female students (Gender =2): 54.51 vs. 51.98 (F =43.09, Sig.<0.001).
- Ethnicity. Students of African American, Latinx, and Native American are grouped together as under-represented (Ethnicity =1) while students of other races, such as Asian-American, White, Visa-Noncitizen and Other/Unknow/Mixed, are grouped together (Ethnicity =2). We observe positive main effect of Ethnicity: students of under-represented races score on average 52.25, which is significantly lower than that of other races: 54.07 (F = 41.92, Sig.<0.001).
- Enrollment. Part-time students (Enrollment =1) perform better in Total than full-time students (Enrollment=2): 54.15 vs. 52.97 (F = 5.612; Sig. = 0.018).

- Transfer. When comparing Total performance of students transferred from community colleges (Transfer =1) with those who didn't (Transfer =2), we find the former group perform better (53.43 vs. 53.18; F=4.209, Sig.=0.040).
- Language. Students who communicate best in English are grouped together (English group; Language =1); those who communicate equally well in English and another language are in one group (Bilingual group; Language =2); and those who communicate better in a language other than English are in the third group (Non-English group; Language =3). English speakers perform marginally better than the other two groups in Total (53.60 vs. 52.29 vs. 52.14; F = 2.828; Sig.=0.059).
- Age. Students are assigned to groups based on their age categories of (1) 20-25; (2) 26-30; (3) 31-35; (4) 36-40; (5) above 40. The means of Total performance for each group is presented in Table 4A. The overall trend is that as students become older, their performance improves, with the exception that students above 40 demonstrate the lowest performance scores. However, the test result still shows positive and significant Age effect (F=3.700; Sig. =0.005).

TABLE 6
UNIVARIATE ANALYSIS TEST OF BETWEEN SUBJECT EFFECTS OF TOTAL BAT PERFORMANCE BY COVID AND DEMOGRAPHIC VARIABLES

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	45044.813[a]	33	1364.994	15.164	0.000
Intercept	916705.653	1	916705.653	10183.902	0.000
Covid	1544.459	1	1544.459	17.158	0.000
Major	9374.181	2	4687.091	52.070	0.000
Ethnicity	3773.443	1	3773.443	41.920	0.000
Enrollment	505.135	1	505.135	5.612	0.018
Work	262.894	4	65.724	0.730	0.571
Gender	3879.103	1	3879.103	43.094	0.000
Age	1332.385	4	333.096	3.700	0.005
Language	509.070	2	254.535	2.828	0.059
Transfer	378.832	1	378.832	4.209	0.040
Covid * Major	539.925	2	269.963	2.999	0.050
Covid * Ethnicity	197.753	1	197.753	2.197	0.138
Covid * Language	1640.561	2	820.281	9.113	0.000
Covid * Enrollment	11.182	1	11.182	0.124	0.725
Covid * Work	902.578	4	225.644	2.507	0.040
Covid * Gender	48.607	1	48.607	0.540	0.462
Covid * Age	634.259	4	158.565	1.762	0.134
Covid * Transfer	67.500	1	67.500	0.750	0.387
Error	359700.621	3996	90.015		
Total	11867181.000	4030			
Corrected Total	404745.434	4029			

a. R Squared = .111 (Adjusted R Squared = .104)

Collectively, the primary impacts of Majors, Ethnicity, and Gender on students' Total BAT performance align with the widely recognized influence of learners' demographic characteristics on academic outcomes (Allen and Bycio, 1997; Bycio and Allen, 2007; Bielinska-Kwapisz and Brown, 2013; Engelhardt et al., 2021; Settlage and Settlage, 2011). Our findings lend support to Hypothesis 2.

We then further explore whether it is the quantitative subject questions or the qualitative ones that contribute to these main effects. Scores from Accounting, Economics, Finance, Statistics and Supply Chain Management questions are combined to form Quantitative score (max=55), while scores from Management, Management Information Systems, Marketing, International Business and Ethics questions are added to form Qualitative score (max=30). We present the means and standard deviations of these two variables by Covid in Panel A of Table 7. Both performance measures improve during COVID. Furthermore, as demonstrated in Panel B and C of Table 7, the improvement is statistically significant for both measures. The average Quantitative score increases from 31.11 to 33.75 (F= 14.926, sig. <0.001), and average Qualitative score changes from 20.23 to 21.72 (F=13.370, sig. <0.001). The effects of previous significant demographic variables remain mostly significant, with the exception of Language on Quantitative scores, and Enrollment, Age and Transfer on Qualitative performance. As such, the main effect of Covid, Major, Ethnicity and Gender remain robust for both Quantitative and Qualitative scores, providing additional support for Hypotheses 1 and 2.

Testing of Hypotheses 3 and 4

Finally, we investigate the effect of Covid on gender and ethnicity gap, or the lack of, as predicted in Hypotheses 3 and 4. According to the univariate ANOVA results with Total BAT score as the dependent variable in Table 6, there is no significant interaction effect between Covid and Gender, or between Covid and Ethnicity, suggesting no change in gender or ethnicity gap during COVID. We then report similar univariate ANOVA results in Table 7 with Quantitative scores (Panel B) and Qualitative scores (Panel C) as the dependent variable. Again, Covid x Gender is not significant in either model, suggesting the gender gap of BAT performance is not affected by COVID, supporting Hypothesis 3. The result is consistent with prior findings that female students are no worse impacted by COVID than males (Engelhardt et al., 2021).

As to Covid x Ethnicity, the interaction effect is not significant with Quantitative scores (F=0.867; Sig.=0.352), but significant for Qualitative BAT performance as the dependent variable (F= 4.516, Sig. =0.034). The interaction effect is also plotted in Figure 3. As shown in Panel A of Figure 3, although all students' Qualitative performance improves during Covid, such improvement is less pronounced in under-represented ethic groups (from 20.01 to 21.24), comparing to that of other races (from 20.37 to 22.11). In other words, the average performance gap between under-represented and other races increases by 146.7%, from 0.356 before Covid to 0.879 afterwards. As a result, we partially support Hypothesis 4: finding no change in ethnicity gap in Quantitative scores, but larger ethnicity gap in Qualitative scores.

TABLE 7
MEANS AND ANOVA BETWEEN SUBJECT TEST RESULTS OF QUANTITATIVE AND QUALITATIVE BAT PERFORMANCE

Panel A: Means of Quantitative and Qualitative BAT Performance

Covid		Quantitative (out of 55)	Qualitative (out of 30)
0-before Covid N=2,089	Mean	31.11	20.23
	Std. Dev.	6.161	3.101
1-during Covid N=1,941	Mean	33.75	21.72
	Std. Dev.	7.901	4.290
Total N=4,030	Mean	32.38	20.95
	Std. Dev.	7.174	3.794

Panel B: ANOVA Between Subject Test Results of Quantitative BAT Performance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	29136.929[a]	33	882.937	19.795	0.000
Intercept	341692.231	1	341692.231	7660.400	0.000
Covid	665.766	1	665.766	14.926	0.000
Major	10368.217	2	5184.109	116.223	0.000
Ethnicity	1698.164	1	1698.164	38.071	0.000
Enrollment	325.566	1	325.566	7.299	0.007
Work	74.585	4	18.646	0.418	0.796
Gender	3049.708	1	3049.708	68.371	0.000
Age	886.678	4	221.670	4.970	0.001
Language	149.063	2	74.532	1.671	0.188
Transfer	193.438	1	193.438	4.337	0.037
Covid * Major	320.008	2	160.004	3.587	0.028
Covid * Ethnicity	38.666	1	38.666	0.867	0.352
Covid * Language	678.109	2	339.054	7.601	0.001
Covid * Enrollment	11.632	1	11.632	0.261	0.610
Covid * Work	446.433	4	111.608	2.502	0.040
Covid * Gender	60.769	1	60.769	1.362	0.243
Covid * Age	273.439	4	68.360	1.533	0.190
Covid * Transfer	26.151	1	26.151	0.586	0.444
Error	178241.638	3996	44.605		
Total	4432988.000	4030			
Corrected Total	207378.567	4029			

a. R Squared = .141 (Adjusted R Squared = .133)

Panel C: ANOVA Between Subject Test Results of Qualitative BAT Performance

Corrected Model	3555.572[a]	33	107.745	7.908	0.000
Intercept	139056.650	1	139056.650	10205.599	0.000
Covid	182.174	1	182.174	13.370	0.000
Major	84.069	2	42.034	3.085	0.046
Ethnicity	408.831	1	408.831	30.005	0.000
Enrollment	19.641	1	19.641	1.441	0.230
Work	63.788	4	15.947	1.170	0.322
Gender	49.819	1	49.819	3.656	0.056
Age	64.924	4	16.231	1.191	0.312
Language	165.226	2	82.613	6.063	0.002
Transfer	30.862	1	30.862	2.265	0.132
Covid * Major	32.365	2	16.182	1.188	0.305
Covid * Ethnicity	61.533	1	61.533	4.516	0.034
Covid * Language	209.572	2	104.786	7.690	0.000

Covid * Enrollment	0.004	1	0.004	0.000	0.986
Covid * Work	87.291	4	21.823	1.602	0.171
Covid * Gender	0.678	1	0.678	0.050	0.823
Covid * Age	80.364	4	20.091	1.475	0.207
Covid * Transfer	9.623	1	9.623	0.706	0.401
Error	54447.602	3996	13.626		
Total	1826885.000	4030			
Corrected Total	58003.173	4029			

a. R Squared = .061 (Adjusted R Squared = .054)

Additional Analysis

Surprisingly, we observe significant interaction effect of Covid x Major; Covid x Work; Covid x Language in main model with Total BAT performance as the dependent variable (Table 6). As we repeat the univariate ANOVA analysis with Quantitative and Qualitative scores as the dependent variables separately (Table 7 Panel B and C respectively), we find that the above three interaction effects are mainly due to Quantitative scores in BAT performance. As presented in Figure 2 Panel A, while Qual majors perform the worse before Covid and improve the most afterwards (from 28.87 to 31.93), Quan majors improve less (from 32.93 to 35.28) while Double majors improve the least (from 33.47 to 34.07), hence the interaction effect (F=3.587; sig.=0.028). This could be due to Double majors already performing well before COVID and having relatively less room to improve. Similarly, we present the interaction graph between Covid and Language in Panel B of Figure 2. This interaction is mainly due to the drastic improvement of non-English preferred students during Covid. Before Covid, this group perform the worst comparing to English preferred and bilingual students, afterwards they perform the best. Online testing environment often presents fewer distractions than face-to-face settings. These platforms typically emphasize reading instruction over listening, which can be advantageous for students who are more comfortable with languages other than English. This allows them to focus more on problem solving without the added stress of listening comprehension. Bilingual group improve the second best, followed by English preferred students. We report and plot the significant interaction between Covid and Work in Panel C of Figure 2. Students are grouped into 5 categories based on hours worked per week: (1) 0-10 hours; (2) 11-20; (3) 21-30; (4) 31-40; and (5) above 40. Interaction between Covid and Work is characterized by the uneven Quantitative performance improvement for students of various Work group. Students with the highest and the lowest weekly work hours improve the most (3.46 and 3.26), followed by those with moderate (Work=3) to high (Work=4) weekly hours, (2.91 and 2.15), while students with relatively low weekly work hours (Work =2) improve the least (1.51).
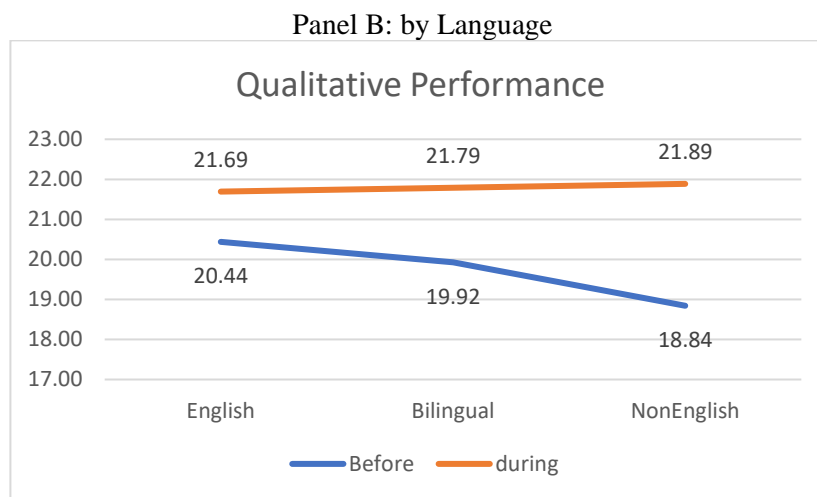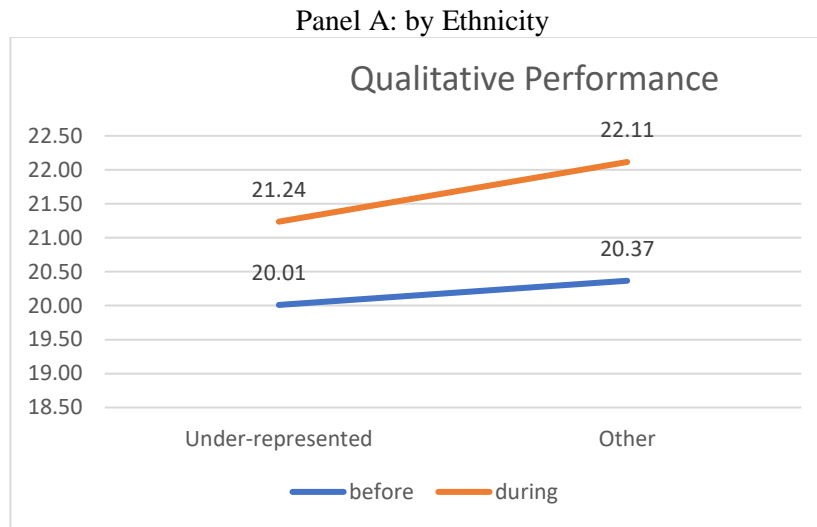
Finally, we also find significant interaction between Covid and Language (F= 7.690, Sig. <0.001) with Qualitative BAT performance as the dependent variable. We present the interaction effect in Panel B of Figure 3. Again, this interaction is mainly driven by the drastic improvement of non-English preferred students (from 18.84 to 21.89) during COVID, comparing to Bilingual group (from 19.92 to 21.79) and English preferred (from 20.44 to 21.69). Before Covid, non-English preferred students perform noticeably worse than the other two groups, but such performance gap disappears during COVID, meaning online testing can be an equalizer for bilingual and non-English preferred with respect to Qualitative BAT performance.

FIGURE 2
QUANTITATIVE PERFORMANCE: INTERACTION EFFECT

Panel A: By Major, Before and During Covid

Panel B: By Language

Panel C: By Work
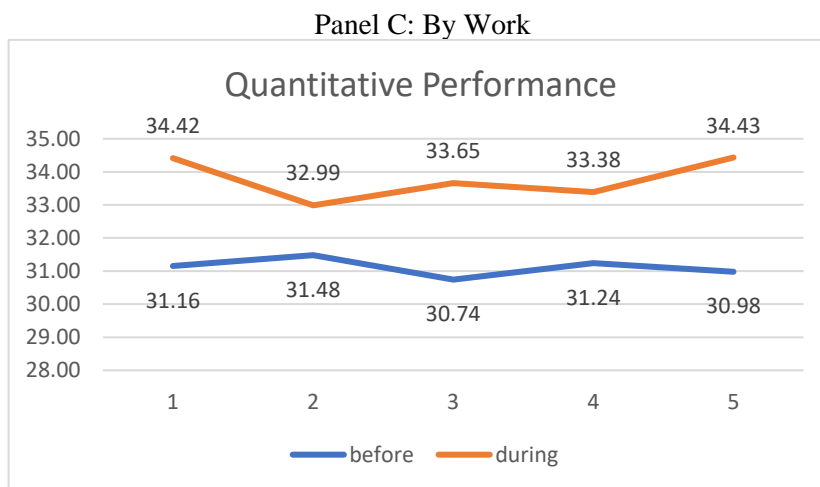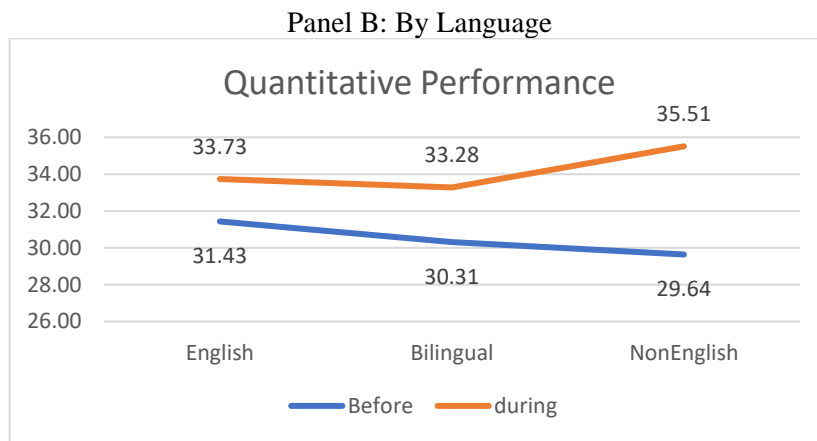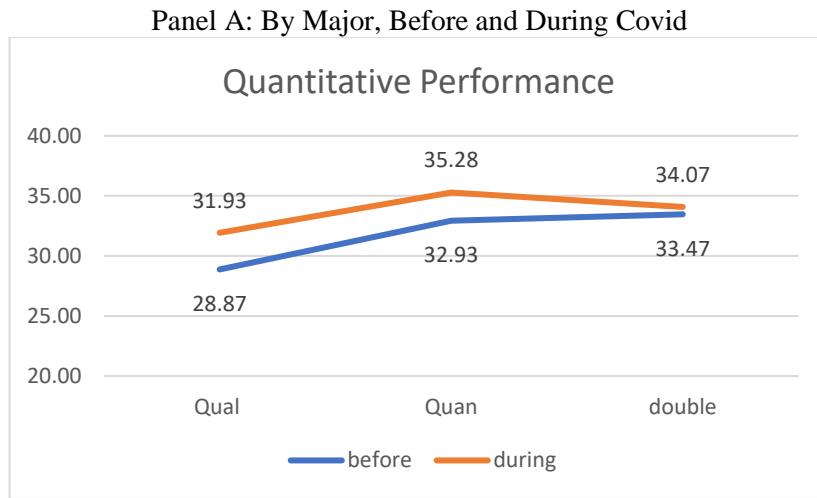
FIGURE 3
QUALITATIVE PERFORMANCE: INTERACTION EFFECTS

Panel A: by Ethnicity

Panel B: by Language

CONCLUSION

Despite efforts by many publishers to improve their online course platforms over the past decade, institutional barriers have hindered the agile adoption of these platforms to some extent. The COVID pandemic, which began in March 2020, exposed the fragility of digital capacities and the fragmentation of tech support across the higher education system. However, the COVID pandemic has emphasized the dire need for effective instruction delivery and testing procedures in higher education institutions. The objective of this study is to present our experience of implementing the online assessment format of the Business Assessment Test (BAT) during the pandemic and to compare the BAT results of students when transitioning from in-person assessment format to the online format at a public university in Southern California.

This study analyzes over 4,000 observations of students' BAT scores from Spring 2017 to Spring 2022, covering both pre- and COVID-eras. We investigate the impact of COVID on BAT scores and whether there are any significant interaction effects between COVID and other demographic factors such as Major, Gender and Ethnicity. After excluding the spring 2020 semester, a transition period with partly face-to-face instruction, the remaining semesters are divided into two groups: before COVID (spring 2017 to fall 2019)

and during COVID (fall 2020 to spring 2022). We find that more students enrolled as part-time students and more students of under-represented races enrolled during COVID than before. We also observe that students are older, more likely to be native English speakers, and more likely to have transferred from community colleges. The analyses show a significant change in student BAT performance during COVID, with the average BAT score improving from 51.35 to 55.47, supporting Hypothesis 1 that students' BAT performance during COVID is no worse than that of before COVID affected semesters.

Our study reveals several main effects on student Total BAT performance. Specifically, Quan and Double Majors outperform Qual Majors in the Total BAT scores. Ethnicity also has a significant effect, with students from under-represented races scoring an average of 1.82 lower than students from other racial groups. Gender also plays a role, as male students outperform female students by 2.52. Additionally, we observe an overall trend of improved performance as students become older, except for those over 40 who demonstrate lower performance scores. English speakers perform marginally better than non-native speakers. Comparing students who transferred from community colleges with those who didn't, we find that the former group perform slightly better. These findings align with the well-established impact of demographic characteristics such as major, gender and ethnicity on academic outcomes and support Hypothesis 2.

We then delve deeper into the effects of Covid and demographic variables on students' BAT scores by investigating whether it is the quantitative or qualitative subject questions that contribute to the observed main effects. We find that the main effects of Covid, Major, Ethnicity, and Gender remain robust for both Quantitative and Qualitative BAT scores, providing additional support for both Hypotheses 1 and 2. The effects of other demographic variables also remain mostly significant, with some exceptions such as Language on Quantitative scores, and Enrollment, Age, and Transfer on Qualitative performance.

Our study reveals significant interaction effects of Covid with Major, Work, and Language on students' Quantitative performance. We find that Double majors perform the best before Covid and demonstrate little improvement during Covid, while Quan and Qual majors improve significantly. The online testing environment helps non-English preferred students concentrate on problem-solving without being stressed by listening comprehension. Before Covid, non-English preferred students perform the worst among the three language groups, but during Covid, they perform the best. For Qualitative BAT performance, we report significant interactions between Covid and ethnicity, as well as Covid and language. Although all students show improved qualitative performance during Covid, underrepresented ethnic groups exhibit less pronounced improvement compared to other races. The interaction effect of Covid x Language for Qualitative performance mimics that for Quantitative performance. Overall, we report no interaction effect of Covid and Gender. The performance gap between male and female students in both qualitative and quantitative performance does not change during COVID. Hence, Hypothesis 3 is supported. However, the Ethnicity gap in the Quantitative BAT scores between under-represented learners and their counterparts intensifies during both time periods, partially rejecting Hypothesis 4.

In summary, our findings demonstrate that student BAT performance does not worsen when switching to online testing during COVID, and the interaction effects between Covid and various factors such as major, language and ethnicity should be considered when evaluating student performance. Our results provide valuable insights for educators and policymakers planning for online assessment formats in the future.

ENDNOTES

1. For a complete list and description of the demographic variables, please see Appendix.
2. Among these 1,941 students, 249 are in asynchronous sessions in which students take the BAT test at their own convenience during a 48-hour window; the rest are in the synchronous sessions in which they take the test during class time on zoom with monitoring. Data analysis comparing these two groups has revealed no statistically significant difference in Total performance between groups. Hence the student performance of these two groups are combined together.

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APPENDIX

Variable coding is as follows:
   Major
      1. Qualitative Majors: General Business, Human Resources Management, International Business, Management, and Marketing
      2. Quantitative Majors: Accounting, Economics, Finance, Information Systems, and Supply Chain Management

    3.   Double Major
Ethnicity
    1.   Under-represented: African-American; Latino/Latina; Native American/Alaskan Native
    2.   Other: Asian-American; Visa, Non-Citizen; White; Other/Unknown (including mixed race)
Enrollment
    1.   Part-Time
    2.   Full-Time
Work
    1.   0-10 hours
    2.   11-20 hours
    3.   21-30 hours
    4.   31-40 hours
    5.   Above 40
Gender
    1.   Male
    2.   Female
Age
    1.   20-25
    2.   26-30
    3.   31-35
    4.   36-40
    5.   More than 40
Language
    1.   I communicate best in English. (English preferred)
    2.   I communicate equally well in English and another language. (bilingual)
    3.   I communicate better in another language than English. (non- English preferred)
Transfer Student
    1.   Yes
    2.   No
Semester
    1.   Spring 17
    2.   Fall 17
    3.   Spring 18
    4.   Fall18
    5.   Spring19
    6.   Fall 19
    7.   Spring 20
    8.   Fall 20
    9.   Spring 21
    10. Fall 21
    11. Spring 22
Covid:
    0.   semester 1-6 (Before COVID)
    1.   semester 8-11 (During COVID)

Total: total number of questions answered correctly, out of 85 questions.
Quantitative: Total number of Accounting, Economics, Finance, Management Information Systems, Statistics and Supply Chain Management questions answered correctly, out of 55 questions.
Qualitative: Total number of Marketing, Management, International Business and Ethics questions answered correctly, out of 30 questions.