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Pedagogical practices and the gender gap in economics education

Bryan Engelhardt | Marianne Johnson | Sarinda Siemers

Economics Department, University of Wisconsin Oshkosh, Oshkosh, Wisconsin, USA

Correspondence
Bryan Engelhardt, Economics Department, University of Wisconsin Oshkosh, Oshkosh, WI, USA.
Email: engelhab@uwosh.edu

Abstract

Since the 1970s, economists have regularly documented that women tend to underperform otherwise comparable men in introductory economics courses. Hypotheses as to why this finding is so persistent often target economists' pedagogical practices. In this paper, we leverage the changes forced by the COVID-19 pandemic to explore several hypotheses. Leveraging a sample of more than 3000 students enrolled in introductory micro- and introductory macroeconomics across seven semesters, we examine the interaction between gender and course modality, returns to effort, and the composition of the final grade. We find the size of the gender performance gap, as measured by course grade, fluctuated significantly across pre-, during, and post-pandemic semesters. We conclude this variation is not explained by course modality or student effort measures; instead, we argue that assessment strategy may drive much of the gender gap. This suggests the de-emphasis of multiple-choice exams in grade composition may go a significant way to closing the gender gap in introductory economics performance.

KEYWORDS

course modalities, gender gap, multiple-choice testing, online learning, student effort, student learning outcomes

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1 | INTRODUCTION

The "gender gap" in economics encompasses a set of interrelated challenges that have long defied simple explanations. One gap persists in the choice to study economics. Women under enroll in high school and collegiate economics courses. Disproportionately few women become economics majors or matriculate into economics graduate programs, and women economists are underrepresented at all levels in academe (Ahlstrom & Asarta, 2019; Bedard et al., 2021; Buckles, 2019; Pugatch & Schroeder, 2021). The reasons why are myriad. They include the experiences of women in the classroom (Ahlstrom & Asarta, 2019; Allgood & McGoldrick, 2021; Bayer et al., 2020; Bayer & Wilcox, 2019; Benjamin et al., 2020; Emerson et al., 2012), ontological and methodological aspects of the study of economics as they relate to the interests of women (Ahlstrom, 2018; Bayer et al., 2020; Chari & Goldsmith-Pinkam, 2017; Emerson et al., 2018; Fiala et al., 2022), a lack of role models and mentoring (Canaan & Mouganie, 2021; Ginther et al., 2020; Lundberg & Stearns, 2019; Porter & Serra, 2020), an unfriendly social climate (Dupas et al., 2021), and discriminatory treatment (Casselman, 2021).

A second gap persists in economic performance, first identified nearly a half-century ago (Bolch & Fels, 1974; Siegfried, 1979). Since, studies continue to find that women receive lower course grades and see lower test scores than otherwise comparable men in introductory economics courses.[1] Though there is compelling evidence of feedback loops between the two gaps, we focus on the latter. Pedagogical practices hypothesized to contribute to women's underperformance include the reliance on high-stakes, multiple-choice testing (Greatz & Karmini, 2022; Montolio & Taberner, 2021), the extensive use of mathematical and graphical models (Ballard & Johnson, 2004; Emerson et al., 2018), the invisibility of women in textbooks and readings (Stevenson & Zlotnick, 2018), and the default adoption of formal lecturing over more active learning strategies (Allgood & McGoldrick, 2023; Asarta et al., 2022). Also relevant may be gendered differences in attitudes and expectations regarding grades, feedback, and course performance (Ballard & Johnson, 2005; Bayer & Wilcox, 2019; Bedard et al., 2021; Rask & Tiefenthaler, 2008).

One of the challenges to empirical exploration of these various pedagogically focused hypotheses has been the difficulty of generating sufficient within the institution, within the department, and within instructor variation in the teaching and grading practices that may affect student outcomes. It is in this context that we can view the changes forced by the COVID-19 pandemic as something akin to a natural experiment in teaching methods. In this paper, we leverage pandemic adjustments to explore several hypotheses of the gender performance gap in introductory economics courses.

Across almost 4 years and roughly 3000 students, we find that the gender performance gap fluctuated significantly. Indeed, the gap almost disappeared early in the pandemic, only to return to near pre-pandemic levels several semesters later. Understanding how and why the gender performance gap has changed in response to pedagogical changes has important implications, not the least because grades earned in introductory economics are known to affect major choice, particularly for women (Noble Calkins & Welki, 2006; Kugler et al., 2021; Rask & Tiefenthaler, 2008). We find little evidence to suggest that the observed variation can be attributed to either course modality or student effort. Instead, we propose that assessment may drive

[1]Although Johnson et al. (2014) documented that the gender gap in student course performance declined in both magnitude and statistical significance between 1980 and 2013, that women receive lower grades and test scores remains a persistent finding in the literature.

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much of the difference. This suggests the de-emphasis of multiple-choice exams in grade composition may go a significant way to closing the gender gap in introductory economics performance (Data S1).

2 | REVIEW OF THE LITERATURE

2.1 | The performance gender gap in introductory economics

Beginning in the 1970s, a series of empirical studies indicated that men were regularly outperforming women on introductory economics exams and in introductory economics courses (Bolch & Fels, 1974; Siegfried, 1979; Siegfried & Strand, 1977). Commonly offered explanations included stereotyped cultural expectations for women that discouraged an interest in business studies as well as the speculated inferior spatial and mathematical skills of women. For example, Allison (1982) attributed the performance differential to men's more developed analytical and theoretical skills. From the start, however, there were clues that pedagogical choices may affect student outcomes. Siegfried and Strand (1977) found that in contrast to the usual classroom setting, women enrolled in a self-paced economics course did relatively better than men. "This suggests a difference in the structure of the relationship between sex and understanding economics on the basis of instructional method" (Siegfried & Strand, 1977, p. 247).

Since, a variety of hypotheses targeting instructional methods have emerged to explain the performance gap. Research on learning styles suggested economists' reliance on chalk-and-talk lecturing meant they often failed to reach students who preferred a more active learning environment (Harmon et al., 2015; Jensen & Owen, 2003). Such mismatch led Boatman, Courtney, and Lee to conclude "gender-based differences in student performance may be at least partially explained by differences in learning style preferences" (Boatman et al., 2008, p. 38). Although evaluations of recent strategies designed to directly engage students in the classroom suggest that most students benefit from active learning, regardless of learning style or gender (Ahlstrom, 2021; Allgood et al., 2015; Bowen et al., 2014; Espey, 2018; Johnson & Meder, 2021),[2] more than 80% of economics instructors continue to rely on traditional lecturing for content delivery in introductory courses (Asarta et al., 2022).

In addition to how class time is organized, classroom atmosphere may also contribute to the gender gap (Benjamin et al., 2020; Dupas et al., 2021; Dynan & Rouse, 1997; Ferber, 1984). Prejudice in favor of men—whether explicit, implicit, or structural—can alienate and discourage women students (Casselman, 2021; Ferber, 1984). So too can the field's communication conventions, particularly when combined with perceptions of (a lack of) support, the lower subject self-confidence of women in courses with significant mathematical or technical content, and their greater sensitivity to what they perceive as low grades (Ballard & Johnson, 2005; Dupas et al., 2021; Ferber, 1984; Golden, 2015; Rask & Tiefenthaler, 2008). Fellow students may compound the problem. Parades et al. (2023) find that male economics students exhibit greater gender bias than students in other disciplines, and the bias becomes more pronounced following the completion of an introductory economics course.

[2]Common active learning strategies include the use of automated response systems (clickers), flipped classrooms, discussion, team problem solving, and games and simulations. Allgood et al. (2015) provide a detailed overview of the research on these various alternative pedagogies.

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Alternatively, the gender gap may be an artifact of how performance is measured. For nearly all introductory economics instructors, exams determine a significant portion of the course grade. Walstad and Miller's (2016) survey suggests that exams account for roughly 70% of course grades in introductory economics and quizzes make up another 20% of students' grades, on average. Both quizzes and exams tend to rely heavily on multiple-choice questions—in fact, 80% of surveyed instructors reported their exams were entirely multiple-choice. Quizzes are also predominantly multiple-choice, as are roughly half of the assigned homework (Walstad & Miller, 2016). The widespread adoption of automated online homework systems in introductory courses has increased the share of homework points deriving from multiple-choice questions.

While the large-lecture format commonly adopted for introductory economics courses can explain both the heavy reliance on exams and the use of multiple-choice questions, the choice may disproportionately disadvantage women (Boulatoff & Cyrus, 2022). "High stakes" testing rewards knowledge over effort. Numerous studies since Siegfried (1979) have demonstrated that men tend to matriculate in introductory economics courses with higher baseline knowledge than women, giving them an initial advantage in the course (e.g., Ballard & Johnson, 2005; Bedard et al., 2021). The use of multiple-choice questions may further exacerbate the gender gap because of differences in cognitive reasoning, risk aversion, question bias, and differential item functioning (Karle et al., 2022; Montolio & Taberner, 2021; Riener & Wagner, 2017; Walstad & Robson, 1997). One theory for the gender performance gap suggests that women are more sensitive to risk-taking, which manifests in skipping more exam questions, particularly when wrong answers are penalized (Karle et al., 2022; Riener & Wagner, 2017). Others have suggested that adverse reactions to difficult questions may more strongly influence the performance of women on subsequent questions; there is some evidence that this reaction can be mitigated with partial credit (Calimeris & Kosack, 2020; Cipriani, 2018). Indeed, a handful of studies have demonstrated that women outperform otherwise comparable men in introductory economics when essay tests or more wholistic grading schemes are used (Jensen & Owen, 2003; Lumsden & Scott, 1987). Further, when grades include a significant effort or conscientiousness component, women also demonstrate an advantage (Espey, 2018; Greatz & Karmini, 2022). The low weight placed on participation and attendance by many economics instructors may work to mitigate any inherent advantage women have in collegiate studies—and this can explain why when economics grades are compared to overall GPA, women underperform.[3]

2.2 | The impact of the COVID-19 pandemic on instructional practices

In March 2020, universities pivoted to fully online learning in response to the uncertainty associated with the outbreak of the SARS-CoV-2/COVID-19 virus. The following two semesters were characterized by an institutionally idiosyncratic mix of course delivery modalities, including in-person, synchronous online, asynchronous online, and hyflex and hybrid courses that offered some option of in-person attendance. At both the institutional and instructional levels, testing and grading policies were amended (Johnson et al., 2021). The teaching of introductory economics was not immune to the changes (Allgood & McGoldrick, 2023; Barile et al., 2022; Bhanot, 2023; Chaudhury, 2023; Engelhardt et al., 2021). Nearly 90% of economists surveyed

[3]Walstad and Miller (2016) report that less than 10% of course grades in introductory economics courses tend to be composed of participation or attendance; fewer than 30% of instructors use short-answer or essay questions.

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reported making significant changes to the classes they taught in fall 2020 and spring 2021 (Allgood & McGoldrick, 2023). Instructors adopted new course delivery modalities—either by force or by choice. They also moved away from whiteboard-dependent lecturing and increased the importance of discussion boards and other engagement activities. And though Allgood and McGoldrick concluded that "the pandemic did not have much impact on how faculty assessed their students" (Allgood & McGoldrick, 2023, p. 187), others suggested the pandemic caused them to reduce the importance of in-class exams in favor of more content-rich assignments (Bhanot, 2023; Filson, 2023).

Preliminary evaluations of student learning during the pandemic have produced mixed results. Engelhardt et al. (2021) identified little impact of the initial COVID shutdown on student learning outcomes in introductory undergraduate economics courses, whether measured by course grade or student performance on a standardized course assessment. Intriguingly, the result common to introductory economics courses, that women receive statistically significantly lower grades than otherwise comparable men, disappeared in the first pandemic-affected semester. Comparing pre- and post-pandemic outcomes, Elizinga and Harper (2023) similarly documented little difference in student performance in a principle of macroeconomic course. In contrast, Orlov et al. (2020) found that pandemic-affected students performed substantially worse on a standardized end-of-semester knowledge assessment than students in past years. Yet, while true on average, Orlov et al. (2020) reported that the pandemic eliminated the usual observed gender penalty. Rodríguez-Planas (2022) found that flexible grading policies benefitted low-income students, but there was no difference in GPA by gender. Elizinga and Harper (2023) also identified little impact of pandemic-induced changes in instructional modality on course grades in an introductory economics course. Both before and during the pandemic, they found a negative but not statistically significant penalty for women students in the course, when controlling for other factors.

The pedagogical adjustments imposed by the COVID-19 pandemic offer an interesting opportunity to empirically evaluate some of the hypotheses offered for the gender gap in course performance. In the next section, we outline some of the instructional changes observed at the institution, including changes in pedagogical delivery, course modality, grading, and classroom atmosphere. We also consider the demographic and academic characteristics of students who enrolled in introductory economics over seven semesters.

3 | FRAMEWORK AND DATA

3.1 | Overview

We examine all sections of principles of microeconomics and principles of macroeconomics taught over seven semesters at a regional, state university located in the upper Midwest of the United States. At the time, the university had an undergraduate student enrollment of ~11,000. Students are predominantly female (61%) and white (81%); 44% are of the first generation in their family to attend college.[4] While most of the students who enroll in Principles of Economics do so to meet the entrance requirements for the College of Business, some students select these courses to meet general education social science requirements or because the courses are

[4]While women generally outnumber men at most colleges and universities in the United States, the disparity at the institution can be attributed to large colleges of education and nursing.

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required by a nonbusiness major. Course enrollments in principles of economics can vary but are limited to 55 students. Honors sections are limited to 25 students.

Data were collected along several vectors: student characteristics and effort, instructor characteristics, and course characteristics. Variables were chosen partly to conform with previous studies of the gender performance gap and partly to facilitate our efforts to assess the impact of classroom modality and grading practices on the gender gap. Student demographic information, GPA, course modality, and final grades were provided by the university's Office for Institutional Research.[5] Instructor characteristics and grading policies were gathered from course syllabi and departmental information. Last, effort measures including course page views and whether students completed a course-specific online assessment quiz were retrieved from an online learning management system (Canvas).[6] Given our interest in the interaction between course performance, gender, and pedagogical practice, we divide our data into four time periods. The two semesters prior to the pandemic (spring 2019 and fall 2019) serve as our control. The two semesters fully affected by pandemic-induced changes to teaching (fall 2020 and spring 2021) are designated as the experimental semesters. Last, we classify the subsequent two semesters (fall 2021 and spring 2022) as post-experimental. The spring 2020 semester is treated as a separate shock.

In Table 1, we provide overall summary statistics for the students in our sample; we also compare the estimates across the relevant time periods. The sample includes 1077 students enrolled in the control period, 837 students enrolled during the experimental semesters, and 895 students enrolled post-experiment. An additional 413 students were enrolled in the spring 2020 shock semester. Students were primarily in their first or second year of college (82.7%), white (82.6%), and male (64.6%).[7] Excepting the gender ratio, Principles of Economics students reflect the university population generally.

We find few statistically significant differences in student characteristics across the different time periods.[8] The exception is student course grades. In the control period, students averaged a 2.45 (slightly better than a C) in introductory economics courses; the average rose to 2.89 in the shock semester and 2.54 in the subsequent experimental semesters. These differences were statistically significant. ($p < .01$). Post-pandemic, grades declined to 2.37, slightly but not statistically significantly lower than in the control period. Because the institution embargoed faculty from mandating student attendance or using attendance as a grade component during the pandemic, we attempt to capture student engagement or effort via two blunt instruments: (i) "Canvas page views," the university's online course management system, and (ii) whether the student completed an end-of-course assessment quiz. Only a handful of studies have considered the usefulness of the engagement statistics generated by online course management systems (Jones, 2022; Rahrough et al., 2018).

[5]Our IRB was approved as IRB Protocol E21-41: Learning Under Covid (October 18, 2022) under the category of exempt human subject research. Because there was no experimental aspect, no deception, and minimal risk, we were not required to secure student permission.

[6]As part of our AACSB assurance of learning, all students in introductory microeconomics and macroeconomics are asked to take a course-specific assessment quiz. The 20-question quiz is identical across all sections of the same course. The assessment is administered as an online quiz through Canvas. Instructors have the option of requiring the assessment as a grade component or offering the assessment as an extra credit opportunity.

[7]Students at the institution self-report gender at the time of matriculation; they are able to update their information at any time. The three options for gender are female, male, and undisclosed. In our sample, no student recorded undisclosed.

[8]The only other notable change was class status, which saw a significant increase in the proportion of first-year students enrolling in introductory economics. We attribute the shift to a backlog of students who delayed college enrollment during the pandemic.

TABLE 1 Student demographic characteristics by time period.

Student characteristics	Overall mean or proportion (standard deviation)	Control spring 2019 and fall 2019	Shock spring 2020	Experimental fall 2020 and spring 2021	Post-experimental fall 2021 and spring 2022
Course grade	2.508 (1.262)	2.454 (1.233)	2.890*** (1.120)	2.541 (1.276)	2.365 (1.309)
Female	0.354	0.369	0.368	0.325*	0.358
Class status					
First-year	0.451	0.406	0.448	0.416	0.540***
Sophomore	0.376	0.340	0.378*	0.411***	0.318
Junior	0.134	0.142	0.145	0.136	0.117**
Senior	0.039	0.058	0.0291	0.037	0.046
First-generation	0.403	0.423	0.414	0.387*	0.389*
Non-white	0.174	0.177	0.174	0.149	0.193
Transfer student	0.178	0.209	0.173***	0.182**	0.139***
Cumulative GPA	2.848 (0.738)	2.857 (0.683)	2.956*** (0.639	2.897 (0.724)	2.742*** (0.839)
Canvas course page views	361.209 (310.852)	192.093 (177.651)	296.780*** (197.812)	487.580*** (385.593)	347.783*** (282.266)
Did not take assessment quiz	0.277	0.216	0.208	0.393***	0.275***

Note: *Indicates statistical significance at the 10% level; ** at the 5% level, and *** at the 1% level for variables relative to the control semester. For the 37 students in their first semester and who matriculated with no incoming collegiate credit, we use their end-of-semester GPA exclusive of their economics course grade as a control for academic aptitude.

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Little consensus exists beyond the fact that such metrics are noisy. We find both page reviews and whether a student completed the assessment quiz to be weakly positively correlated with course grade ($r = .38$) and overall GPA ($r = .31$). Unsurprisingly, the shift to online learning during the pandemic was associated with a statistically significant increase in Canvas page views ($p < .01$); page views have since declined but remain higher than in the pre-pandemic era ($p < .01$).

In Table 2, we consider whether there is a significant variation in grades or effort by gender. During the control period, we observe the usual finding that women earn lower grades in introductory economics. In our sample, women earned an average grade of 2.363 in the control period compared to an average grade for men of 2.508 ($p = .06$).[9] Little difference is observed in student inclination to do the assessment or in assessment scores by gender. In the initial control semesters, the point estimate of "pass rate," or those completing the course with a C or better, indicates that men slightly outperform women.[10] In contrast, women passed the course at a statistically significantly higher rate during the initial shock semester, with no difference observed in subsequent semesters. Where we do identify additional variation is in Canvas page views. Women have a higher number of page views over the course of the semester than men; this result transcends all time periods ($p < .01$).

To better understand what happened to course grades, we go beyond a simple t test to compare the distribution of grades. In the first image in Figure 1, we compare the distribution of course grades across the three time periods using a kernel density plot. The plot suggests grades at or above a 2.0 (C) appear more uniform prior to the pandemic, with grades trending distinctly higher throughout the pandemic-affected semesters. This is most evident in the top-grade category of 4.0 (A). Subsequent images indicate that the pandemic had a heterogenous impact by gender. The usual grade penalty experienced by women pre-pandemic disappeared in the pandemic-affected semesters; during this time, women became less likely to fail and more likely to earn an A. Although post-pandemic, men have regained a grade advantage, but the difference is now visually smaller.

3.2 | Course content, structure, and assessment

At the institution, micro- and macroeconomics are taught as one-semester introductory-level courses. Neither course has a prerequisite. In both, opportunity cost, production possibility frontiers, and supply and demand are required content. Additional topics required in microeconomics include elasticity, theory of the firm, perfect and imperfect competition, and monopoly. Once this baseline is met, instructors can choose to cover other topics at their discretion. Required topics in macroeconomics are the measurement of total output, income, inflation, and unemployment, aggregate demand and aggregate supply, fiscal policy, and money and monetary policy. Although there is no common textbook, consistency is gained from AACSB accreditation standards. Specifically, all introductory courses have shared course objectives, a regular review of syllabi, and incorporate a common end-of-semester assessment quiz.[11] Over the seven semesters, nine different professors taught at least one section of introductory economics. All were tenured or tenure-track faculty; two were female. All instructors relied

[9]The cumulative GPA for women averages 3.01 compared to an average cumulative GPA for men of 2.76 ($p < .01$).

[10]Grades below a "C," including a "C−," are indicated as zero; a grade of C or above are coded as one. Because students must complete both microeconomics and macroeconomics with a grade of C or better to be admitted to the College of Business, a C is considered the "passing" threshold.

[11]Assigned textbooks included those by Acemoglu, Laibson, and List, Krugman and Wells, McConnell, Brue and Flynn, Mankiw, and the OpenStax textbook of Shapiro, MacDonald, and Greenlaw.

TABLE 2 Differences in course grade and engagement by gender.

Course outcomes and choices	Women mean/ proportion (SD)	Men mean/ proportion (SD)	*t*-test of difference of means/proportions (*p*-value)
Course grade			
Overall	2.496 (1.281)	2.515 (1.251)	−0.412 (.680)
Control semesters	2.363 (1.314)	2.508 (1.182)	−1.869 (.062)*
Shock semester	3.066 (1.105)	2.788 (1.151)	2.447 (.014)**
Experimental semesters	2.522 (1.252)	2.550 (1.289)	−0.291 (.771)
Post-experimental semesters	2.367 (1.297)	2.364 (1.317)	0.029 (.977)
Proportion of students who earned a grade of C or higher			
Overall	0.798	0.811	−0.901 (.368)
Control semesters	0.761	0.816	−2.181 (.029)**
Shock semester	0.921	0.877	1.387 (.165)
Experimental semesters	0.820	0.814	0.199 (.842)
Post-experimental semesters	0.766	0.770	−0.163 (.871)
Assessment quiz score (%)			
Overall	0.726 (0.146)	0.738 (0.144)	−1.906 (.057)*
Control semesters	0.723 (0.141)	0.734 (0.139)	−1.104 (.270)
Shock semester	0.734 (0.142)	0.730 (0.148)	0.218 (.827)
Experimental semesters	0.730 (0.140)	0.746 (0.154)	−1.099 (.272)
Post-experimental semesters	0.723 (0.158)	0.744 (0.132)	−1.822 (.069)*
Proportion of students who did not complete the assessment quiz (non-completion rate)			
Overall	0.270 (0.444)	0.282 (0.500)	−0.707 (.480)
Control semesters	0.227 (0.419)	0.210 (0.408)	0.630 (.529)
Shock semester	0.184 (0.389)	0.222 (0.417)	−0.916 (.360)
Experimental semesters	0.386 (0.488)	0.396 (0.490)	−0.289 (.772)
Post-experimental semesters	0.266 (0.442)	0.280 (0.449)	−0.461 (.645)
Canvas page views			
Overall	412.046 (338.676)	333.728 (291.151)	6.2747 (.000)***
Control semesters	222.944 (199.402)	174.231 (157.067)	3.095 (.002)***
Shock semester	342.816 (207.712)	269.969 (187.050)	3.663 (.000)***
Experimental semesters	555.493 (409.387)	454.885 (369.551)	3.560 (.000)***
Post-experimental semesters	440.006 (328.918)	338.482 (245.510)	5.233 (.000)***

Note: *Indicates statistical significance at the 10% level; ** at the 5% level, and *** at the 1% level.

primarily on lecture to deliver course content.[12] Many used a mix of assessments that included homework, quizzes, exams, and measures of participation or attendance; nonetheless, exams accounted for the vast majority of a student's course grade (see Table 3).

[12]Two of nine instructors used PowerPoint slides, one of whom provided the slides to students via an online course management system (Canvas). A third instructor provided written notes to students via Canvas. Instructors in our sample always used PowerPoint or never used PowerPoint; none reported switching during the study period. We opt for individual instructor control variables over the inclusion of an indicator variable for PowerPoint in the regressions.

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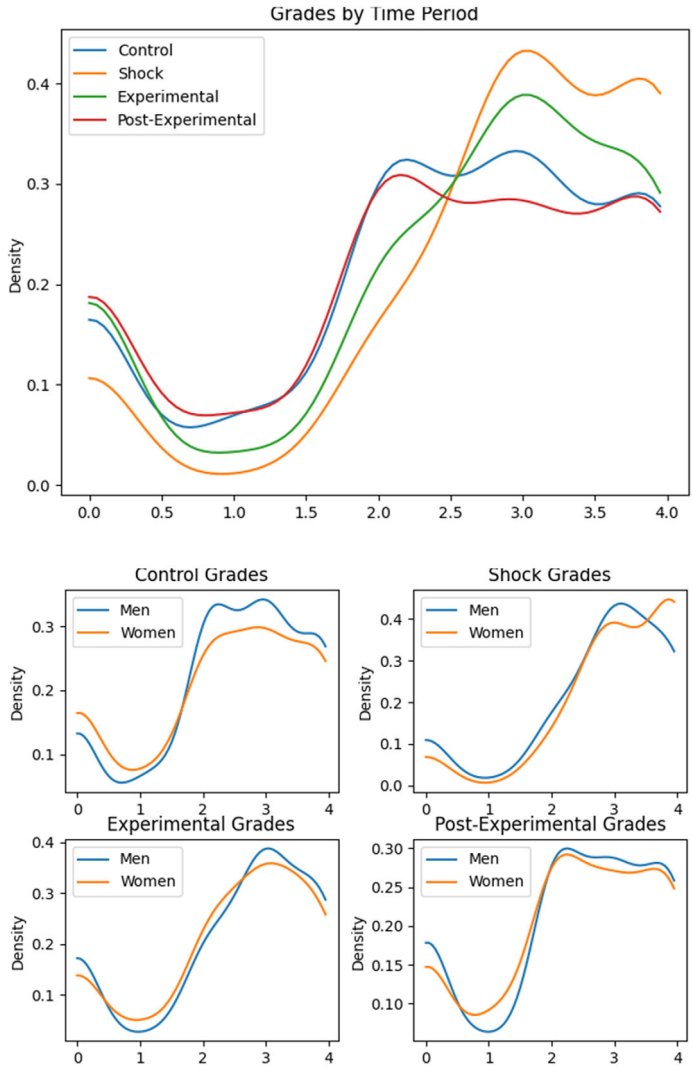


FIGURE 1 Kernel density plots of student grades by gender and time period (The plotted distribution is a kernel density estimation using a Gaussian kernel. The *p*-values of the 2 sample K-S test comparing men and women grades in the control, shock, experimental, and post-experimental periods are 0.261, 0.018, 0.893, and 0.974, respectively). [Color figure can be viewed at wileyonlinelibrary.com]

During the initial control period, all principles of economics courses at the institution were taught in-person (face-to-face); introductory economics instructors unanimously returned to this format in the post-experimental (post-pandemic) period. While initially all courses were scheduled in-person for spring 2020, with the closure of campus in March, instructors were required to adopt either a synchronous or asynchronous online delivery for the remainder of the semester. Given the steep transition costs and the idiosyncratic adoption of delivery methods, we do not report a breakdown between in-person, online asynchronous, or online synchronous for the shock semester.

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In the subsequent experimental semesters, instructors could choose between three primary formats: asynchronous online, synchronous online, or in-person with conditions.[13] The most common modality during the experimental semesters was online asynchronous, enrolling 57.1% of all students. In Table 3, we report the percentage of students enrolled in each of the formats by semester, along with additional course and instructor details.

We find no difference in enrollment patterns by time period. The only notable change in course characteristics was in assessment. Note the decline in the percentage of course points determined by multiple-choice exams from the control to the experimental period ($p < .01$). The shift was motivated by two concerns. First, to increase engagement, particularly of online students, several instructors in our sample began to assign discussion or participation points; others adopted weekly homework or quizzes to get students to log on regularly. Second, concerns regarding student cheating during online, un-proctored exams led some instructors to reduce the importance of exams in favor of alternative assessments.[14] To capture these shifts, we also include variables to indicate the percentage of course points determined by homework or quizzes and the percentage of course points determined by participation, discussion, short-writing assignments, and/or attendance.

From the summary statistics, it seems evident that something changed during the pandemic which affected course grades in introductory economics—and changed in ways that affected women differently than men. However, there remains the question of whether this is true once we control for other factors that may affect student outcomes.

4 | ESTIMATION AND DISCUSSION

4.1 | Theoretical framework and preliminary estimates

We begin by assessing the size and significance of the gap across the seven semesters in our sample using a standard education production function (e.g., Bosshardt & Chiang, 2016; Elizinga & Harper, 2023; Cosgrove & Olitsky, 2016). Equation (1) suggests that student performance is a function of their academic background, demographic characteristics, and the course in which the student was enrolled. The dependent variable (Y) is course grade, measured on a 4.0 scale.[15]

$$Y_{i,k,t} = \alpha + \beta g_{i,t} + \gamma X_{i,t} + \rho Z_{k,t} + \varepsilon_{i,k,t}. \quad (1)$$

[13]During the experimental semesters, two versions of in-person course attendance were attempted. The first was "modified tutorial," where students could attend lectures either in-person or synchronously online, with the caveat that all exams were given in person. Thus, while students could attend lectures online, this modality closely mimicked a traditional in-person course. The second option was "hyflex," where students could attend lectures in-person or synchronously online, with the caveat that all assessments took place online. We therefore group the small number of hyflex sections with the synchronous online sections.

[14]Although available through the institution, none of the introductory economics instructors in our sample chose to adopt anti-cheating software (e.g., Proctorio). In contrast, about half of the department's introductory statistics instructors did make use of anti-cheating options.

[15]Course grade is measured on a 4.0 scale, with the bins defined as 4.0 (A), 3.67 (A−), 3.33 (B+), 3.0 (B), and so forth. We estimated the same specifications reported here using ordered probit with no significant difference in findings. We chose to report WLS results for ease of interpretation; ordered probit findings are available from the authors upon request.

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TABLE 3 Course and instructor characteristics.

Course and instructor characteristics	Total combined mean or proportion (SD)	Control semesters (spring 2019 and fall 2019)	Shock semester (spring 2020)	Experimental semesters (fall 2020 and spring 2021)	Post-Exp. semesters (fall 2021 and spring 2022)
Microeconomics	0.497	0.507	0.525	0.485	0.483
Number of sections					
Microeconomics	36	11	5	11	9
Macroeconomics	31	9	4	9	9
Enrolled in an honors section	0.044	0.038	0.032	0.050	0.053
Scheduled modality					
Synchronous online	0.079	0.000	–	0.304	0.000
Asynchronous online	0.148	0.000	–	0.571	0.000
In-person	0.773	1.000	–	0.125	1.000
Female instructor	0.141	0.224	0.109***	0.035***	0.155***
PowerPoint slides used for lectures	0.207	0.151	0.346***	0.159	0.437***
Percentage of course grade determined by multiple-choice exams	0.791 (0.209)	0.835 (0.116)	0.866*** (0.081)	0.671*** (0.335)	0.815*** (0.118)
Percentage of courses determined by homework or quizzes	0.164 (0.183)	0.117 (0.060)	0.109* (0.080)	0.294*** (0.307)	0.124** (0.065)
Percentage of course grade determined by discussion, short-writing assignments, course participation, and/or attendance	0.045 (0.074)	0.048 (0.075)	0.025*** (0.064)	0.035*** (0.056)	0.061*** (0.075)

Note: *Indicates statistical significance at the 10% level; ** at the 5% level, and *** at the 1% level for variables relative to the control semester with the number of students determining the number of observations. For instructors who assigned homework or quizzes, five used self-generated materials, and four made use of textbook company online learning tools, for example, Connect. Except for one instructor, quizzes were entirely composed of multiple-choice or fill-in-the-blank questions. The same was true for the online homework systems.

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Equation (1) is estimated using weighted least squares with clustered standard errors by the student and weighted by the number of times an individual student appeared in the sample.[16] Course grade (Y) is conditional on the student (i), the semester (t), and the course (k). We separate student gender (g) from other academic experience and demographic data, represented by the vector $X_{i,t}$. The regression also includes a vector of course and instructor characteristics, including instructor-specific dummies ($Z_{k,t}$).

Our results are consistent with the typical findings of the economics education literature (Table 4). We confirm the importance of cumulative GPA as a control for academic aptitude and effort. Note that for first-semester students who matriculated without any collegiate credit, we use end-of-semester GPA exclusive of their economics course grade as a proxy for cumulative GPA.[17] Nonwhite students and first-generation college students face a penalty in their introductory economics courses compared to otherwise equivalent peers; however, only the latter finding is statistically significant across all regression specifications.[18] Students who enrolled in either synchronous or asynchronous online classes saw grades that were roughly one-third of a grade point lower than their peers enrolled in sections with in-person learning ($p < .01$)—and this was despite grades trending higher throughout the shock and experimental semesters.

Consistent with the literature, we find that in the initial control semesters, women's course grades were ∼0.22 of a grade point lower than those of otherwise comparable men ($p < .01$). Intriguingly, much of this gap was closed in the first pandemic-affected semester before returning to previous levels. Understanding what contributes to the gender gap is especially important in the context of a literature that suggests women evince greater sensitivity to grades when choosing a major (Noble Calkins & Welki, 2006; Kugler et al., 2021; Rask & Tiefenthaler, 2008).

4.2 | Modalities and the gender gap

We take advantage of the within-instructor variation generated by the closure of campus to in-person learning to consider the impact of course modality on the gender performance gap. As we noted, prior to the pandemic, all introductory economics courses in our sample were offered in-person. To examine the interaction between modality and student learning outcomes, we modify the education production function of Equation (1) to include the key explanatory variables, c_t and pc_t, is equal to 1 if the student was enrolled in a pandemic-affected semester or in the post-pandemic semesters as well as an indicator for the course modality (d). Interactions between gender, pandemic time period, and modality are considered.

[16]Weighting is necessary as many individuals appear in the data set twice, once in introductory macroeconomics and once in introductory microeconomics. In some cases, students took the classes in the same semester. In addition, students who failed to achieve a C in either of the courses may appear additional times, seeking to meet the minimum entrance requirements for the business school.

[17]While we would have preferred to use a measure such as math ACT or cumulative ACT test score as a control for academic aptitude following Elizinga and Harper (2023), the suspension of ACT testing in Spring 2020 and the university's subsequent choice to waive test scores as an admissions requirement means we have almost no data for students who matriculated in Fall 2020 or after. Current university policy is that the submission of scores is optional.

[18]None of the estimated coefficients differ in sign, magnitude, or significance from those reported in Table 5.

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$$Y_{i,k,t} = \alpha + \beta g_{i,t} + \gamma X_{i,t} + \rho Z_{k,t} + \eta c_t + \delta pc_t + \tau d_{k,t} + \varepsilon_{i,k,t}. \quad (2)$$

The vector of student academic characteristics remains the same as for the initial regressions, as does the vector of instructor and course characteristics. We retain instructor-specific dummies throughout all specifications, estimated using weighted least squares. Results are reported in Table 5.

Cumulative GPA remains the most important indicator of course grade both by magnitude and significance. A one-point gain in a student's cumulative GPA is associated with a 1.06 gain in introductory economics course grade ($p < .01$) across all four specifications in Table 5. Transfer and honors students are predicted to earn about a tenth of a grade point higher. First-generation college students earn about a tenth of a grade point lower than otherwise equivalent students ($p < .01$). Finally, we note nonwhite students are predicted to see a penalty of ~0.06 of a grade point, although the result is not statistically significant.

Students enrolled during the experimental semesters could expect to earn 0.39 of a grade point higher than students in the control semesters. However, these gains were entirely offset for students in online courses (Specification 1). There was no difference in performance between students in asynchronous and synchronous online sections. These results are robust across the addition of interactions between gender and time period (Specification 2) and between gender and course modality (Specification 3). Since the students were informed about course modality at the time of enrollment and because some courses allowed for different modalities across sections and instructors, students had at least some ability to self-select into their preferred format. The poorer outcomes observed in online classes could be driven either by some uncontrolled student characteristic that led them to choose online learning over in-person attendance or by something inherent to the nature of online course delivery. Both are commonly identified as explanations in the literature (e.g., Anstine & Skidmore, 2005; Krieg and Henson, 2016).

Women are predicted to earn 0.22 of a grade point lower than men, holding other factors constant ($p < .01$). This result is remarkably robust across the specifications, with the exception of the shock semester (Specifications 2 and 4). However, we see no evidence that women are particularly sensitive to course modality (Specification 3). Taken together, there is little here to support the hypothesis that escape from the traditional classroom environment can work to mitigate the gender gap. Indeed, though some have speculated that women may have an advantage in online classes either due to the change in classroom atmosphere or because online courses tend to place a greater weight on effort or diligence (Brown & Liedholm, 2002; Gratton-Lavoie & Stanley, 2009), there is little consistency across these studies as to the interplay between course modality and gender. For example, Cosgrove and Olitsky (2016) found the advantage for men persists across traditional, blended, and web-based classes in their study of online learning. In contrast, Gratton-Lavoie and Stanley (2009) found women in online sections of introductory economics largely closed the performance gap, though the gap persisted in blended (hybrid) sections. See also Bettinger et al. (2017), Craft and Linsak (2020), Figlio et al. (2013), Wozny et al. (2018).

4.3 | Effort, assessment, and the gender gap

Alternative explanations for the gender performance gap have focused on grading policies, including economists' heavy reliance on multiple-choice exams in introductory economics and

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TABLE 4 Estimated gender coefficient by semester and time period.

	Estimated coefficients (standard error)
Female	−0.222 (0.046)***
Female * shock semester	0.149 (0.085)*
Female * experimental semesters	−0.025 (0.070)
Female * post-experimental semesters	−0.040 (0.577)
Class (control is first-year)	
Sophomore	−0.026 (0.030)
Junior	0.022 (0.047)
Senior	0.163 (0.074)**
Cumulative GPA	1.065 (0.020)***
Nonwhite	−0.057 (0.040)
Transfer student	0.147 (0.038)***
First generation student	−0.084 (0.028)***
Microeconomics	−0.038 (0.076)
Honors	0.130 (0.047)***
Spring semester	0.090 (0.029)***
Modality (control is in-person)	
Asynchronous online	−0.378 (0.100)***
Synchronous online	−0.384 (0.092)***
Time period (control is pre-pandemic semesters)	
Shock	0.100 (0.059)*
Experimental	0.390 (0.093)***
Post-experimental	−0.017 (0.046)
Constant	−0.125 (0.105)
R-squared	.640

Note: The use of * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

a corresponding minimization of effort components. We consider these in Equation (3), which adds to the vector of course characteristics ($Z_{k,t}$) the fraction of course points determined by multiple-choice exams and by participation (inclusive of attendance and discussion). We also add two blunt effort measures: Canvas page views (online learning management system) and whether the student completed an end-of-semester assessment quiz ($W_{i,k,t}$).

$$Y_{i,k,t} = \alpha + \beta g_{i,t} + \gamma X_{i,t} + \lambda W_{i,k,t} + \rho Z_{k,t} + \eta c_t + \delta pc_t + \tau d_{k,t} + \varepsilon_{i,k,t}. \quad (3)$$

The dependent variable remains final course grade. Additional specifications include interactions between gender and the fraction of course grade determined by multiple-choice exams (6) and between gender and the fraction of the course grade determined by participation (7) and our effort measures (8). All interactions are included in the ninth specification. We retain instructor-specific dummies throughout. Results are reported in Table 6. In the

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TABLE 5 Course modality and the gender gap.

	Initial specification[a] (1)	With gender and time interaction (2)	With gender and course modality interaction (3)	With all interactions (4)
Female	−0.222 (0.028)***	−0.222 (0.046)***	−0.217 (0.031)***	−0.222 (0.046)***
Female-time interaction				
Female * shock	–	0.149 (0.085)*	–	0.149 (0.086)*
Female * experimental		−0.025 (0.070)		−0.044 (0.142)
Female * post-experimental	–	−0.040 (0.071)	–	−0.040 (0.071)
Female-modality interaction				
Female * asynchronous online	–	–	−0.115 (0.100)	0.059 (0.151)
Female * synchronous online	–	–	0.010 (0.077)	−0.065 (0.164)
Class				
Sophomore	−0.026 (0.030)	−0.026 (0.030)	−0.026 (0.030)	−0.027 (0.030)
Junior	0.019 (0.047)	0.022 (0.047)	0.018 (0.047)	0.020 (0.047)
Senior	0.161 (0.074)**	0.163 (0.074)**	0.163 (0.074)**	0.164 (0.074)**
Cumulative GPA	1.065 (0.020)***	1.065 (0.020)***	1.065 (0.020)***	1.065 (0.020)***
Nonwhite	−0.056 (0.040)	−0.057 (0.040)	−0.055 (0.040)	−0.056 (0.040)
Transfer	0.147 (0.038)***	0.147 (0.038)***	0.147 (0.038)***	0.147 (0.038)***
First generation	−0.085 (0.028)***	−0.084 (0.028)***	−0.086 (0.028)***	−0.084 (0.028)***
Microeconomics	−0.036 (0.077)	−0.038 (0.076)	−0.035 (0.077)	−0.037 (0.076)
Honors	0.131 (0.047)***	0.130 (0.047)***	0.133 (0.047)***	0.131 (0.047)***
Spring semester	0.091 (0.029)***	0.090 (0.029)***	0.091 (0.029)***	0.091 (0.029)***
Modality (control is in person)				
Asynchronous online	−0.386 (0.003)***	−0.384 (0.093)***	−0.389 (0.098)***	−0.404 (0.121)***
Synchronous online	−0.377 (0.010)***	−0.378 (0.100)***	−0.345 (0.106)***	−0.361 (0.127)***

(Continues)

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TABLE 5 (Continued)

	Initial specification[a] (1)	With gender and time interaction (2)	With gender and course modality interaction (3)	With all interactions (4)
Time (control is pre-pandemic)				
Shock	0.155 (0.047)***	0.100 (0.059)*	0.155 (0.047)***	0.100 (0.059)*
Experimental	0.383***(0.087)	0.390 (0.093)***	0.383 (0.087)***	0.397 (0.114)***
Post-experimental	−0.033 (0.037)	−0.017 (0.046)	−0.033 (0.037)	−0.017 (0.046)
Constant	−0.131 (0.104)	−0.126 (0.105)	−0.133 (0.104)	−0.126 (0.105)
R-squared	.639	.640	.639	.640

[a]Standard errors are in parentheses. The use of * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level. We suppress instructor-specific dummies to save space.

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Appendix, we report the estimates of a probit version of the model where the dependent variable is the likelihood of earning a grade C or better in introductory economics.

Little difference is observed in either the estimated coefficients or the statistical significance of the core control variables across the specifications in Tables 5 and 6. However, the inclusion of grading and effort variables provides some interesting insights into the habits and behaviors that may affect student grade outcomes. First, we find that the fraction of course points determined by multiple-choice exams is negatively and statistically significantly related to course grade, though the overall effect is small. Each 10% increase in the fraction of course points earned via multiple-choice exams is associated with a course grade decline of 0.09 ($p < .01$). In contrast, a 10% increase in course points earned via participation or related activities is associated with a notable 0.73 increase in course grade ($p < .01$). Further, we find that although Canvas page views are not related to course performance in any of the specifications, students who failed to complete the end-of-semester assessment could expect to see a course grade of half a letter grade less, even after controlling for GPA ($p < .01$). Controlling for these variables goes some way to mitigating the negative impact of taking synchronous online classes; however, the penalty associated with asynchronous online classes remains steep and statistically significant.

In Specification 5, we again observe the standard grade penalty for women remains despite including variables of effort and grading practices. Indeed, there is no evidence to suggest that women see a greater return to effort as measured by Canvas page views or as noncompletion of the end-of-semester assessment (Specification 8). Nor is there evidence to suggest women earn a greater premium from course participation opportunities (Specification 7). In none of these specifications are the interaction terms between female and effort or female and participation statistically significant; further, the grade penalty for women remains at roughly one-quarter of a letter grade ($p < .01$).

What does seem to matter for women is the extent to which multiple-choice exams determine final course grades (Specification 6). While all students see a penalty as the percentage of course points determined by multiple-choice exams increases, it is steeper for women. Each 10% increase in course points assigned via multiple-choice test is associated with a decline for women of 0.11 in their final course grade, measured on a 4.0 scale. Note that when the interaction between female and the fraction of course points determined by multiple-choice exams is included, we see that both the size and significance of the coefficient on female decreases (specification 6). This finding persists in the final specification (9), where we predict women will earn grades equivalent men. Given the suggestion in Figure 1 that the gender gap changed primarily in the upper tail of the distribution, we consider five additional regressions in the Appendix, In these probit regressions, we examine the likelihood a student earns a C or better (a pass) in their introductory economics course, conditional on the same variables in Specifications 5 to 9 of Table 6. Generally, women are significantly less likely than otherwise comparable men to pass introductory economics ($p < .01$; Specifications 10, 12, and 13). This penalty disappears when we include the interaction term between female and percent of course grades determined by multiple-choice exams (Specifications 11 and 14).

Although these findings likely raise more questions than they answer, we argue that the results regarding exam and grade composition are suggestive. Previous studies have found that the gender gap in course performance shrinks or disappears when introductory economics course grades are determined by essay exams (Jensen & Owen, 2003; Lumsden & Scott, 1987) or rely on a more balanced mix of exams, homework, group work, and/or participation (Boulatoff & Cyrus, 2022; Epsey, 2018). While such measures have traditionally only been undertaken in classes with small enrollments, technological innovations, including AI, may

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TABLE 6 Grading, effort, and the gender gap.

	Initial specification[a] (5)	With gender and exam interaction (6)	With gender and participation interaction (7)	With gender and effort interactions (8)	With all interactions (9)
Female	−0.259 (0.029)***	−0.089 (0.087)	−0.279 (0.034)***	−0.255 (0.048)***	0.010 (0.134)
Female * exam %	–	−0.002 (0.001)**	–	–	−0.003 (0.001)**
Female * participation %	–	–	0.004 (0.004)	–	0.003 (0.004)
Female * Effort					
Female * page views	–	–	–	0.000 (0.008)	−0.006 (0.001)
Female * noncompletion of assessment	–	–	–	−0.024 (0.072)	−0.101 (0.086)
Class					
Sophomore	−0.016 (0.031)	−0.015 (0.031)	−0.015 (0.031)	−0.016 (0.032)	−0.014 (0.032)
Junior	0.016 (0.047)	0.012 (0.047)	0.017 (0.048)	0.017 (0.047)	0.016 (0.047)
Senior	0.143 (0.084)*	0.143 (0.084)*	0.144 (0.084)*	0.143 (0.084)*	0.146 (0.083)*
Cumulative GPA	0.923 (0.023)***	0.923 (0.023)***	0.923 (0.023)***	0.932 (0.023)***	0.923 (0.023)***
Nonwhite	−0.048 (0.043)	−0.049 (0.043)	−0.048 (0.043)	−0.050 (0.043)	−0.047 (0.043)
Transfer	0.141 (0.040)***	0.143 (0.040)***	0.140 (0.040)***	0.141 (0.040***	0.141 (0.040)***
First generation	−0.098 (0.029)***	−0.097 (0.029)***	−0.098 (0.029)***	−0.098 (0.029)***	−0.097 (0.029)***
Microeconomics	0.037 (0.071)	0.037 (0.071)	0.037 (0.071)	0.037 (0.071)	0.038 (0.071)
Honors	0.642 (0.080)***	0.642 (0.080)***	0.634 (0.081)***	0.646 (0.082)***	0.656 (0.083)***
Spring semester	0.098 (0.040)**	0.100 (0.040)**	0.100 (0.040)**	0.099 (0.040)**	0.102 (0.039)**
Percent grade that is multiple choice exams	−0.009 (0.001)***	−0.009 (0.001)***	−0.009 (0.001)***	−0.010 (0.001)***	−0.009 (0.001)***

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TABLE 6 (Continued)

	Initial specification[a] (5)	With gender and exam interaction (6)	With gender and participation interaction (7)	With gender and effort interactions (8)	With all interactions (9)
Percent grade that is participation	0.073 (0.009)***	0.073 (0.009)***	0.071 (0.009)***	0.073 (0.009)***	0.071 (0.009)***
Effort measures					
Canvas page views/100	0.006 (0.001)	0.006 (0.005)	0.006 (0.005)	0.006 (0.007)	0.008 (0.007)
Noncompletion of assessment	−0.474 (0.056)***	−0.476 (0.056)***	−0.475 (0.056)***	−0.467 (0.059***	−0.448 (0.060)***
Modality					
Asynchronous online	−0.263 (0.094)***	−0.263 (0.093)***	−0.266 (0.093)***	−0.264 (0.094)***	−0.269 (0.093)***
Synchronous online	−0.022 (0.061)	−0.024 (0.111)	−0.027 (0.113)	−0.022 (0.113)	−0.030 (0.112)
Time					
Shock	0.225 (0.064)***	0.256 (0.064)***	0.256 (0.064)***	0.255 (0.064)***	0.254 (0.065)***
Experimental	−0.001 (0.106)	−0.001 (0.105)	0.002 (0.106)	−0.001 (0.106)	0.003 (0.105)
Post-experimental	−0.149 (0.048)***	−0.148 (0.048)***	−0.150 (0.048)***	−0.149 (0.048)***	−0.150 (0.048)***
Constant	−0.607 (0.222)***	−0.664 (0.224)***	−0.596 (0.224)***	−0.610 (0.223)***	−0.700 (0.227)***
R-squared	.678	.679	.679	.678	.679

[a]Standard errors are in parentheses. The use of * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level. We suppress instructor-specific dummies to save space. We do not have page view information for students enrolled in Spring 2018 because the institution had not yet fully implemented Canvas. This reduces our sample size to 2335.

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enable automatic or semi-automatic grading of exam formats other than multiple-choice. One encouraging technology is the ability to award partial credit for multiple-choice questions either via immediate question retakes or software that allows for more sophisticated automatic grading (Calimeris & Kosack, 2020). When combined with online tracking of discussion boards and/or group work, instructors now have access to a range of relatively low-cost tools that allow them to reduce their reliance on high-stakes, multiple-choice testing. As teaching innovations pioneered in the pandemic become shared and more regularly deployed (e.g., Barile et al., 2022; Bhanot, 2023; Chaudhury, 2023; Filson, 2023; Orlov et al., 2020), close examination of their impact may identify new strategies to help close the gender gap.

5 | CONCLUSIONS

In this paper, we leverage the pedagogical changes forced by the COVID-19 pandemic to explore several hypotheses for the persistent gender performance gap observed for women in introductory economics courses. As such, this is not a study of the impact of the pandemic on student learning outcomes, but an effort to treat the changes forced by the pandemic as a natural experiment which generated within instructor changes to course format and delivery that can help us parse contributors to the gender gap.

Our results are consistent with the previous literature and suggest new pathways forward. First, we document the intriguing result that the gender performance gap shrunk significantly in the initial semester subject to the COVID-19 shock and fluctuated significantly in subsequent semesters. Although there are yet few studies of student performance in introductory economics during the pandemic period, two have documented similar findings (Engelhardt et al., 2021; Orlov et al., 2020). Second, we find little evidence that the shift to online learning can explain the reduction in the gender gap. Indeed, studies of online learning in introductory economics are largely inconclusive as to the interaction between gender and course modality. Nonetheless, those who have found that women perform equivalently or better than otherwise comparable men in online or flipped courses suggest the explanation lies in the more diligent study habits of women students (e.g., Anstine and Skidmore, 2005; Brown & Liedholm, 2002) than in the change in classroom atmosphere or inherent features of digital learning. Our analysis provides no definitive support for either hypothesis. Third, what does seem to drive the size and significance of the gender performance gap is the proportion of course points determined by high-stakes, multiple-choice exams. Controlling for assessment and including an interaction between female and the proportion of course points earned via multiple-choice exams has the effect of eliminating any observed gender performance gap; in this case, women are predicted to perform equivalently to men. If this holds, the de-emphasis of multiple-choice exams in grade composition may go a significant way to closing the gender gap in introductory economics performance.

The present study has several limitations. First, our sample of college students may not be reflective of undergraduates nationally, thereby limiting the generalizability of results. Additional studies of the gender gap across the pre- to post-pandemic time periods would be welcome and could facilitate additional testing of hypotheses as to why we observe a gender gap in student performance in introductory economics. Second, the dataset we use does not include the use of anti-cheating software. Although Yaniv et al. (2017) do not find a statistically significant difference in cheating between genders in an experiment made up of economics students, our results should be checked with a dataset where anti-cheating software was used. If men or women are more or less likely to cheat, then our results could be impacted. Another limitation

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is the uniform return to in-person learning post-pandemic at the institution. Greater variation in course delivery post-pandemic would likely offer greater clarity on the interaction between gender and course modality. Cross-institutional studies that vary not only in grading practices but also in course enrollments and modalities may provide useful information going forward.

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SUPPORTING INFORMATION

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APPENDIX: PROBIT ANALYSIS, DEPENDENT VARIABLE IS A C OR BETTER IN COURSE

	Initial specification[a] (10)	With gender and exam interaction (11)	With gender and participation interaction (12)	With gender and effort interactions (13)	With all interactions(14)
Female	−0.613 (0.090)***	0.180 (0.346)	−0.714 (0.101)***	−0.452 (0.201)**	0.508 (0.516)
Female * exam %	–	−0.010 (0.004)**	–	–	−0.011 (0.005)**
Female * participation %	–	–	0.025 (0.012)**	–	0.020 (0.012)*
Female * Effort					
Female * page views	–	–	–	−0.000 (0.001)	−0.001 (0.001)
Female * noncompletion of assessment	–	–	–	−0.219 (0.185)	−0.412 (0.021)**
Class					
Sophomore	−0.010 (0.097)	−0.008 (0.097)	−0.002 (0.097)	−0.009 (0.097)	−0.001 (0.098)
Junior	−0.061 (0.129)	−0.074 (0.129)	−0.063 (0.128)	−0.049 (0.129)	−0.056 (0.128)
Senior	−0.155 (0.268)	−0.156 (0.268)	−0.146 (0.266)	−0.152 (0.261)	−0.140 (0.257)
Cumulative GPA	1.057 (0.076)***	1.065 (0.077)***	1.065 (0.077)***	1.061 (0.077)***	1.079 (0.078)***
Nonwhite	−0.232 (0.104)**	−0.233 (0.104)**	−0.228 (0.105)**	−0.227 (0.105)**	−0.224 (0.107)**
Transfer	0.017 (0.130)	0.023 (0.129)	0.011 (0.129)	0.012 (0.127)	0.010 (0.128)
First generation	−0.098 (0.029)	−0.107 (0.085)	−0.104 (0.085)	−0.102 (0.084)	−0.101 (0.085)
Microeconomics	−0.335 (0.225)	−0.342 (0.226)	−0.336 (0.225)	−0.332 (0.225)	−0.335 (0.227)
Honors	1.234 (0.362)***	1.191 (0.356)***	1.131 (0.355)***	1.289 (0.376)***	1.192 (0.366)***
Spring semester	0.324 (0.117)***	0.321 (0.117)***	0.323 (0.117)***	0.327 (0.117)***	0.324 (0.117)***
Percent grade that is multiple choice exams	−0.017 (0.004)***	−0.015 (0.004)***	−0.017 (0.004)***	−0.017 (0.004)***	−0.014 (0.004)***

(Continues)

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	Initial specification[a] (10)	With gender and exam interaction (11)	With gender and participation interaction (12)	With gender and effort interactions (13)	With all interactions(14)
Percent grade that is participation	0.125 (0.036)***	0.125 (0.036)***	0.116 (0.037)***	0.124 (0.036)***	0.117 (0.037)***
Effort Measures					
Canvas page views/100	0.003 (0.000)***	0.003 (0.000)***	0.003 (0.000)***	0.003 (0.001)***	0.003 (0.001)***
Noncompletion of assessment	−1.400 (0.106)***	−1.404 (0.107)***	−1.405 (0.106)***	−1.330 (0.125)***	−1.285 (0.125)***
Modality					
Asynchronous online	−0.146 (0.301)	−0.194 (0.300)	−0.150 (0.301)	−0.140 (0.303)	−0.195 (0.300)
Synchronous online	−0.346 (0.349)	−0.395 (0.353)	−0.356 (0.350)	−0.331 (0.350)	−0.383 (0.353)
Time					
Shock	0.287 (0.204)	0.297 (0.204)	0.299 (0.204)	0.282 (0.204)	0.295 (0.204)
Experimental	−0.369 (0.321)	−0.317 (0.323)	−0.362 (0.323)	−0.377 (0.323)	−0.314 (0.325)
Post-experimental	−0.466 (0.137)***	−0.461 (0.137)***	−0.473 (0.137)***	−0.462 (0.137)***	−0.459 (0.137)***
Constant	−3.082 (0.854)***	−3.326 (0.868)***	−3.055 (0.853)***	−3.141 (0.845)***	−3.470 (0.872)***
Pseudo *R*-squared	.5618	.5633	.5632	.5624	.5658

[a] Standard errors are in parentheses. The use of * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

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