Incentivize or Penalize? Effects on Lecture Attendance and Student Learning Outcomes

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Abstract

This study analyzes whether and how differences in course design and teaching approach affect not only lecture attendance, but also individual and collective learning outcomes. More specifically, we utilize a quasi-natural experiment and exploit variation in attendance policies adopted across four upper-level agribusiness courses to test for differences in course-specific academic outcomes and learning growth. Rather than solely relying on an evaluation of letter grades, we use quantitative measures of overall course performance and improvements in performance. We further provide descriptive evidence of differences in students' learning experiences and sense of belonging. While we find that both mandatory attendance policies and incentivized participation effectively increase lecture attendance, the latter may offer additional benefits. Although they cannot be interpreted as causal evidence, our findings consistently suggest that adopting a student-centered and inclusive teaching approach that incentivizes active engagement (rather than penalizes absences) supports student learning and can contribute to closing academic achievement gaps.

1 Introduction

"Learning results from what the student does and thinks and only what the student does and thinks. The teacher can advance learning only by influencing what the student does to learn." Herbert Simon[1]

The COVID-19 pandemic marked the beginning of a downward trend in higher education enrollment across all demographic groups (Mangan, 2024). The unprecedented disruptions in higher education and devastating losses experienced during this period likely further exacerbated the misperception that success requires eschewing a career in agriculture, particularly among students who grew up in communities comprised of agricultural and food supply workers (Strine, Brewer, and DeLay, 2024). These trends stand in stark contrast to the substantial demand for highly skilled and well-trained college graduates and the numerous well-paid job openings in the fields of finance, food, agriculture, renewable natural resources, and environmental sciences (CDFA, 2023; Supiano, 2023).

The challenges experienced over the last five years have spurred innovations in teaching and revitalized student support services. However, several recent developments, including increased reliance on artificial intelligence tools and severe funding cuts, have intensified existing problems in higher education generally, and in Agricultural Economics and Agribusiness programs specifically (Ratliff et al., 2025). Perhaps the most noticeable and universally agreed-upon challenge is the need to bring students back to the classroom and engage them with course material in ways that support learning and intellectual growth.

Many educators have reverted or are considering reverting to more restrictive approaches, such as implementing mandatory attendance policies and technology bans, often citing readily observable increases in lecture attendance and visible reductions in distractions as direct evidence of the effectiveness of these approaches. Increased workloads and burnout experienced by instructors, faculty, and staff since the beginning of the pandemic, especially those actively involved in undergraduate teaching and mentoring, have further amplified calls to return to an instructor-first perspective that prioritizes instructor well-being and time constraints over student needs (Warner, 2024). Evidence regarding the efficacy of pedagogical innovations introduced during the early stages of the pandemic is still limited, making it hard to advocate for a more nuanced approach that preserves a service-learning focus (Ambrose et al., 2010).

This paper argues that the post-pandemic era, despite its many hardships, also presents an opportunity to leverage differences in course designs adopted to develop data-driven and evidence-based teaching approaches

[1]Quoted in Ambrose et al. (2010), p. 1.

that not only bring students back to the classroom but also better serve diverse student populations and improve educational outcomes. It documents that a continuous commitment to student- and learning-centered teaching approaches can result in significant improvements in students' learning experiences and outcomes.

We study four upper-level electives taught during the 2023-24 academic year in the Managerial Economics major administered by the Agricultural and Resource Economics (ARE) department at the University of California, Davis (UC Davis). Using a combination of administrative student record data, course-specific performance measures, and student survey responses, we empirically assess whether the method by which increases in lecture attendance are achieved matters. More specifically, we compare and contrast the effects of differences in overall course design on student lecture attendance and learning outcomes. We focus on variations in attendance polices, but also acknowledge that the overall teaching approach adopted by the instructors differs more broadly. Our main outcomes of interest are students' overall course performance and course-specific learning growth, the latter of which is defined as the difference in overall course performance recorded at the end of the quarter and performance on the first midterm.

We first document that both courses with mandatory attendance policies in place (e.g., penalizing absences) and courses that incentivize lecture attendance (rewarding students' lecture participation using iClickers) see a considerable increase in lecture attendance compared to courses with no attendance policies. Our regression results suggest that increased lecture attendance is positively correlated with better academic outcomes, but that the means with which instructors achieve increased lecture attendance make a difference. Students in courses with incentivized participation demonstrate relatively greater improvements in academic performance than students exposed to penalized absences. Notably, incentivized participation improved both individual and collective learning outcomes, contributing to the closing of achievement gaps for student populations currently underrepresented in most higher education institutions.

Our quantified measure of learning growth captures students' improved comprehension of the subject matter and course-specific improvements in academic performance. More broadly, learning growth can also be understood as social and emotional growth, as well as the cultivation of greater self-confidence in one's abilities. Our qualitative analysis of student survey responses addresses these dimensions, examining students' learning experiences, sense of belonging, and changes in students' attitudes toward learning and perceptions of their ability. We find that students who are incentivized to be present and participate, rather than penalized for their absences, become relatively more accepting of critical feedback and are less dependent on positive feedback regarding their performance. We also find that learning experiences and sense of belonging vary significantly across self-identified gender, race, and student status (e.g., international versus domestic).

This paper contributes to several different strands of existing literature. First, low in-person lecture attendance is not an entirely new problem in undergraduate courses, especially at R1 institutions. Previous research documented that increased attendance can significantly impact student performance, with regular lecture attendees scoring, on average, a full letter grade higher than their absent peers (Romer, 1993). We expand on this research by comparing two different approaches aimed at increasing lecture attendance, and test not only for differences in their effects on course grades received but also on observed improvements in academic performance throughout the quarter.

Second, our survey design and qualitative analysis of student experiences draw from the emerging literature on experience effects and economic outcomes (Malmendier, 2021; Malmendier and Shen, 2024) and pedagogical research conducted in other STEM disciplines (Edwards, Barthelemy, and Frey, 2021; Edwards et al., 2022). The latter has documented strong recursive relationships between academic performance, retention in STEM disciplines, and course-specific social belonging. Our descriptive analysis suggests that students' sense of belonging and learning experiences can differ significantly not just across diverse student demographics, but also by course design. Finally, we aim to contribute to the search for solutions that can simultaneously address low lecture attendance and declining interest in agricultural economics and agribusiness majors and careers. Our empirical analysis suggests that a continuous commitment to creating inclusive and supportive learning environments that incentivize all students to attend lectures and actively participate in the classroom can re-engage and attract students to our discipline more effectively than penalizing students for their absences.

The remainder of the paper proceeds as follows: Section 2 describes the study design and data. Section 3 presents our regression analysis of overall student performance and learning growth and discusses our main empirical findings. Section 4 summarizes survey responses in a graphical analysis. We discuss our findings and conclude in section 5.

2 Data Analyzed

This study treats differences in the adopted teaching approach across four courses taught during the 2023-24 academic year as a quasi-natural experiment. Our sample includes two offerings of ARE 171: Principles of Finance, one in the fall, and one in the spring, taught by the same instructor (instructor A), scheduled at the same time, and other than the implemented change in attendance policy during the spring, using the same overall course design and assessments. Our sample includes two additional courses taught during the spring quarter: ARE 133 (Introduction to Behavioral Economics) and 136 (Managerial Marketing). The instructor of these two courses (instructor B) opted not to use mandatory attendance policies. They incentivized student participation during lectures and sections and implemented a peer- and project-based learning approach. All three of these courses are upper-level electives taught as large lecture classes with similar enrollment caps. A large share of Managerial Economics students complete all three of these courses before graduation, and most take them in their senior year.

The data for our analysis come from three distinct sources. First, student performance data for each course was collected via Canvas pages. Second, individual student characteristics were collected via administrative student records. These characteristics include academic history (e.g., overall GPA, grade in ARE 100A: Intermediate Microeconomics) and demographic information (e.g., race, ethnicity, First Generation (FG) status, and gender). Third, we administered a survey that asked students about their learning experiences and course-specific sense of social belonging at the end of the spring quarter. Data collection and study design are both IRB-approved and FERPA-compliant.

Our course-level and student performance data consist of 393 observations (the total number of students enrolled in the four courses). Six students dropped one of the courses or did not complete all assignments used to construct our primary performance measures (e.g., were excused from the first midterm), reducing the number of observations to 387. We also recorded 137 survey responses, seven of which were excluded from our analysis because the students answered fewer than half of the survey questions.

2.1 Differences in Teaching Approach and Attendance Policies

We argue that for the purpose of this analysis, the four courses analyzed differ most notably in the attendance policy and overall teaching approach of the instructor. During the fall quarter, instructor A taught ARE 171 without implementing any attendance policies for lectures and relied primarily on exams to evaluate student learning. Instructor A then implemented a mandatory attendance policy (penalizing absences) when teaching this course during the spring quarter. The syllabus states: "If you plan to skip lectures, this course is not for you." Students can miss no more than two lectures without being penalized (see syllabus included in the appendix). Attendance was recorded by teaching assistants positioned at the doors of the large lecture hall at the beginning of each lecture, and students who arrived late were marked as absent.

In contrast, the instructor for ARE 133 and 136 incentivized lecture attendance and active participation by using a student-response software (iClickers). Students were polled frequently during lectures and encouraged to discuss poll questions with peers before submitting their individual responses. After each lecture, one randomly selected question determined the participation points received for that day. One point was assigned if a response was received, and an additional point was assigned if a correct answer was submitted. The overall participation score was censored, allowing for occasional absences. Students were able to opt out of participation (and lecture attendance) entirely and change the weight of other assignments in the calculation of their overall course grade (see syllabi).[2] Instructor B also used a peer- and project-based approach in ARE 133 and 136 and implemented several formative and summative assessments designed to support and assess students' collective and individual learning (see syllabi included in the appendix).

We use these distinct differences to define two treatment groups and one control group for our analysis. We define ARE 171(F) as our control. ARE 171(S), which implemented a mandatory attendance policy that penalizes students, is defined as treatment group 1 (treat 1). ARE 133 and ARE 136 taught during the same quarter are defined as our treatment group 2 (treat 2).

We acknowledge that a variety of factors can contribute to student learning and that these courses differ in more dimensions than lecture attendance policy and teaching approach, including instructor of record, subject matter, time of day lectures are held, and potential systematic differences in characteristics of the students enrolled in these courses. While we are able to control for differences in student characteristics in our analysis, we cannot include instructor or course fixed effects once we define our treatments. Our treatment effects can therefore not solely be attributed to differences in lecture attendance policies and teaching approach, and we will not be able to interpret significant differences detected as causal evidence in favor of either course design. Rather, we test for significant differences in learning outcomes across treatments and, if detected, interpret these as suggestive that the instructor's teaching approach and lecture attendance policy could be one of the contributing factors in determining learning outcomes. In contrast, significant effects of increased lecture attendance, but failure to detect additional differences across treatments, would suggest that it does not matter how increased attendance is achieved. We supplement our discussion of regression results with a more qualitative analysis of learning outcomes for students enrolled in two or more of the analyzed courses. Finally, we summarize data capturing student experiences and sense of belonging based on collected survey responses.

2.2 Select Summary Statistics

Table 1 summarizes the course-level characteristics for the classes in our analysis. All four courses had similar enrollment cutoffs, but enrollment for ARE 133 and 136 is somewhat larger than for ARE 171. A plausible explanation for these observed differences in enrollment is the early start time of ARE 171 (7:30 am). The centralized assignment of lecture rooms with varying setups, capacities, and technical equipment available also resulted in variation in the use of lecture capture across these courses. ARE 136 was assigned

[2] Although this policy has been in place for several quarters, very few students (fewer than 5%) have taken advantage of this option in any given quarter or course.

a room that had not been updated, prohibiting the use of lecture capture. Recorded lectures were made available to students for the other courses in our sample. Although not the focus of our analysis, it allows us to briefly discuss the use of an additional indirect attendance policy. Even when available, instructors are increasingly choosing to opt out of lecture capture in an attempt to promote attendance (i.e, by removing the option to watch lecture recordings afterwards). It is important to note that we surveyed students enrolled in all four classes at the end of the spring quarter and asked them to reflect on their learning experiences and sense of belonging. The significantly lower response rate for ARE 171(F) can at least partially be attributed to the fact that we solicited responses almost a quarter after the course ended.

Table 1: Course-level Summary Statistics

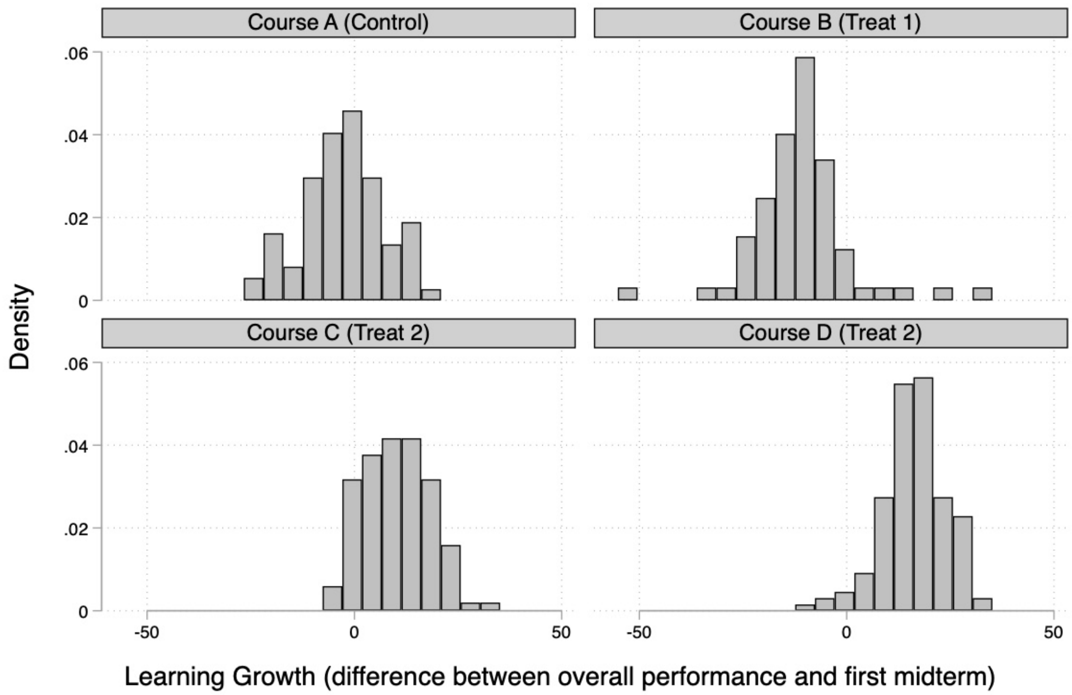
Course	**Control (A)**	**Treat 1 (B)**	**Treat 2 (C)**	**Treat 2 (D)**
Course code	ARE 171	ARE 171	ARE 133	ARE 136
Enrollment	78	69	108	138
Lecture capture available	✓	✓	✓	
Survey response rates	16.6	31.1	32.4	47.8
Lecture attendance required		✓		
Participation incentivized			✓	✓
Course records available	✓	✓	✓	✓
Student records available	✓	✓	✓	✓
Students attending lectures (Avg in %)	11.5	98.9	91.0	87.0
Midterm score (Avg in %)	68.5	77.6	76.6	68.6
Overall course performance at end of quarter (Avg in %)	68.2	65.7	86.8	84.7
Final grade (GPA)	1.95	2.95	3.23	3.04

A first look at lecture attendance indicates that it is significantly higher in both of our treatment groups compared to the control (no lecture attendance policy). Notably, if the primary goal is to get students back to the classroom, mandatory attendance policies seem more effective than incentivized participation. Only 11.5% of students enrolled in ARE 171 during the fall quarter regularly attended lectures, whereas attendance increased to 98.5% during the spring quarter.[3] For ARE 133 and 136, 91 and 87% of students regularly attended lectures. It is worth noting that 91% of students attended ARE 133 lectures, despite the fact that recorded lectures were made available to students, and that this course's lecture attendance is only slightly higher than for ARE 136's (87%). In other words, high lecture attendance for courses defined as treatment 2 is achieved independent of the availability of lecture capture.

Here, we also report average student performance on the (first) midterm and overall course performance (as percentages rather than points received to facilitate comparison across courses). The first midterm often serves as the earliest summative assessment for which students receive substantive feedback. These summary statistics indicate relatively similar mean midterm scores across all courses, although students

[3]The attendance for ARE 171 during the fall reported here is based on the instructor's recollection of who attended class regularly that quarter. Since attendance was dramatically low during this quarter, instructor A was confident in identifying the students who regularly attended lectures. For the remaining three courses, this value is based on the mean attendance or participation score recorded.

Figure 1A: Learning Growth by Course - All Students



perform slightly better in ARE 171(S) and ARE 133 than in ARE 171(F) and ARE 136. In contrast, we detect significant differences in overall course performance, measured as the total or combined score received at the end of the quarter. This statistic suggests significant improvements in performance only for treatment group two. In fact, overall course performance decreases for ARE 171(S) compared to performance in the first midterm.

While our analysis of learning outcomes uses overall course performance measured in percent of all possible points received, and improvements or learning growth measured as the difference between total course and first midterm performance, we also report final grades submitted to the Registrar's office here. Although we see similar mean values for overall course performance for ARE 171 across both offerings, submitted grades for ARE 171 differ by a full grade point. Instructor A was reluctant to curve final grades during the fall quarter because of the extremely low lecture attendance. However, the significantly increased attendance meant that instructor A was willing to curve final grades during the spring. Curving final grades in ARE 171(S) means that grades are closer to the grades assigned in ARE 133 and ARE 136 (B average). Neither of these courses curved final grades. Importantly, noticeable differences in overall course performance and learning growth between treatment 1 and treatment 2 would be masked if we were only using final grades in our analysis.

Figure 1B: Learning Growth by Course - Excluding Top 25%

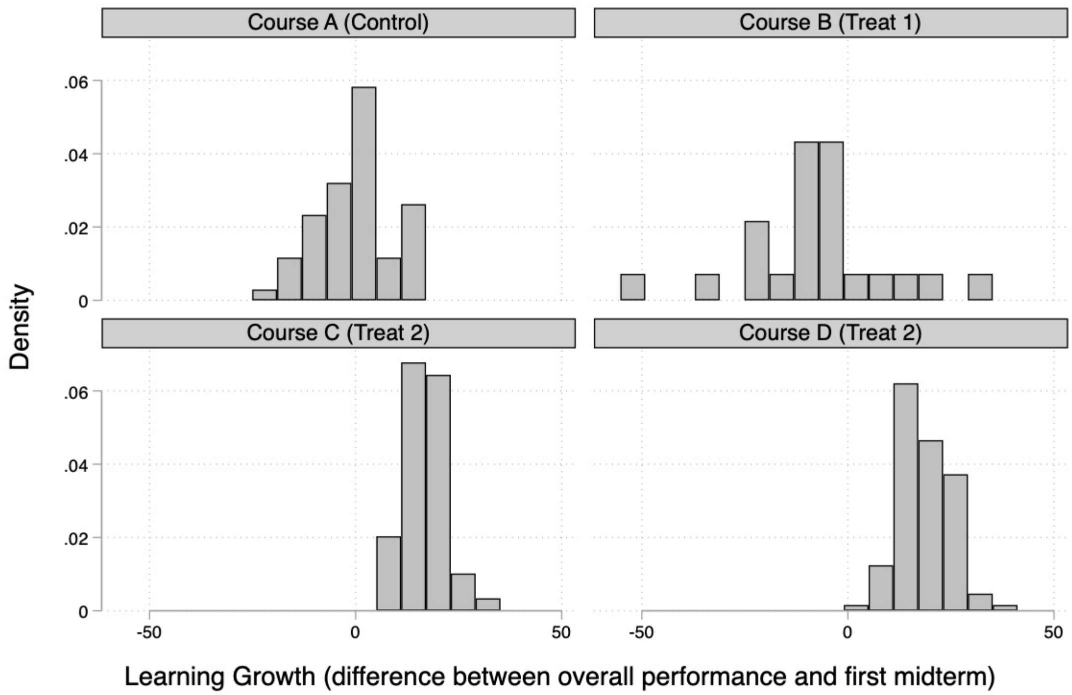


Figure 1A graphs the entire distribution of improvements in performance or learning growth (computed difference in performance at the end of the quarter and the first midterm). It shows that, in addition to the significantly higher mean performance reported in Table 1, the entire distribution shifts to the right in ARE 133 and 136 (treatment 2). In comparison, for the two ARE 171-course offerings, the distributions are centered around zero, or no improvement. This suggests that almost all students experienced learning growth when enrolled in one of the two courses in treatment group 2, while some students improved their performance in ARE 171, and some performed significantly less well than in the midterm. We also examine the distributions of learning growth after excluding the highest-performing students (based on first midterm scores) from each course. Since learning growth is measured as the difference between overall course performance and first midterm performance, students who scored very high on their first midterm (top 25%) may show little to no improvement in this outcome measure. After removing the top-performing quartile from the analysis (Figure 1B), we find that all students in treatment group 2 experience positive learning growth. The distribution for treatment group 1 remains largely similar to that of the control group.

The choice of our improvement or learning growth variable warrants additional exploration. Some courses are designed in a more modular fashion, while others take a cumulative approach. The four courses analyzed here all take a cumulative approach in their assessment of learning throughout the quarter. Regardless of course design and grading policy, it seems reasonable to assume that learning occurred if a student's overall performance at the end of the term was higher than their performance on a single assignment at the beginning of the same term. Conversely, a student with a lower performance overall than on a single assignment at the beginning of the quarter might have understood one aspect of the course but likely learned relatively less overall or experienced less learning growth than a student for whom we observe improvements or increases in overall performance compared to a single assignment given earlier in the quarter. In other words, the ability to incorporate feedback and correct mistakes is a fundamental feature of learning growth.

Table 2: Student-Level Summary Statistics

	Control (A)		Treat 1 (B)		Treat 2 (C)		Treat 2 (D)	
	mean	sd	mean	sd	mean	sd	mean	sd
Starting year	2020.79	1.01	2020.94	0.88	2021.16	0.97	2020.69	0.89
Gender (1=female)	0.39	0.49	0.34	0.48	0.55	0.50	0.52	0.50
First Gen (1=yes)	0.32	0.46	0.38	0.49	0.34	0.47	0.40	0.49
Transfer student (1=yes)	0.33	0.47	0.22	0.42	0.27	0.45	0.24	0.43
AHN (1=yes)	0.13	0.34	0.12	0.32	0.17	0.37	0.15	0.36
Asian (1=yes)	0.63	0.48	0.60	0.49	0.50	0.50	0.60	0.48
Intern. student (1=yes)	0.29	0.46	0.25	0.44	0.11	0.32	0.20	0.40
Participation in EOP (1=yes)	0.14	0.35	0.12	0.32	0.16	0.37	0.17	0.38
Change in major (1=yes)	0.49	0.50	0.57	0.50	0.47	0.50	0.57	0.50
GPA (Fall 2023)	3.09	0.51	3.09	0.48	3.20	0.57	3.16	0.44
Grade received in ARE 100A	2.76	1.02	2.56	1.02	2.70	0.99	2.65	0.97
Numb. of Obs.	80		68		108		138	

In Table 2, we also report summary statistics for student-specific data. The year students arrived on campus can be understood as a proxy for student status. The mean value is similar across all four courses, suggesting that students included in our analysis started prior to or during the pandemic, and that the majority of students enrolled in all four courses were seniors. A smaller percentage of students in ARE 171 identified as female (e.g., 39% or 33% of the students, compared to 55% and 53% in treatment 2), but the percentages of first-generation and transfer students are similar across all four courses. About a third of the students enrolled identified as first-generation, and close to 25% transferred to UC Davis from community colleges or other four-year institutions.[4] The share of racial or ethnic minorities defined as students identifying as AHN is also similar across all four courses and amounts to 13-17%.[5] The remaining students either identify as White or Caucasian or Asian. In fact, the majority of students enrolled in these upper-level electives identify as Asian (rather than White or Caucasian), with percentages ranging from 50 to 63%. Eleven to 25% of the students identifying as Asian are international students.

[4]For UC Davis as a whole, around 30% of students enter as transfer students.

[5]The share of students identifying as Hispanic (10%), Black (2.3%), and/or Native American (2.3%) is relatively small, and separately analyzing each group of students for each course would result in identifying a single student in some cases.

The share of students participating in the campus-wide Educational Opportunity Program (EOP) is similar across all courses as well. EOP provides additional academic guidance, personal and social support, and advice on accessing additional financial resources. Its aim is to strengthen the competency and ability of first-generation and low-income students to meet the demands of an R1 university. Participation in EOP is voluntary, and although all students are able to apply, a large share of students participating in EOP identify as belonging to an ethnic minority, and/or as female or gender non-conforming. By including this indicator variable in our analysis, we aim to capture intersectionality, or potentially compounding effects of being or feeling marginalized based on race, ethnicity, gender, and socio-economic background, as first introduced and defined by Crenshaw (2013).

Finally, we report summary statistics for an indicator capturing whether students changed into the managerial economics major, their cumulative GPA observed at the end of the fall quarter (before enrolling in our treatment courses), and their final grade received in ARE 100A and observe similar mean values across all four courses.[6] We conclude that our sample of course- and student-level data is fairly balanced across all four courses analyzed. Nevertheless, our regression analysis controls for observed differences in students' socio-demographics and academic performance. The inclusion of student-specific controls allows us to detect possible heterogeneous learning outcomes, especially for more vulnerable student populations, for which achievement gaps have been widely documented in the existing literature (e.g. Pascarella et al., 2004; Stephens et al., 2012).

The significantly smaller sample size and unbalanced response rates across courses for our survey responses prevent us from including this additional information in our regression analysis. We do, however, conduct a graphical and more qualitative analysis for these data and discuss our findings in section 4.

3 Estimations & Main Results

We apply an ordinary least squares (OLS) regression framework to address two key questions: (1) What is the impact of in-person attendance on educational outcomes, and (2) Can we detect differential effects on student learning based on how lecture attendance is achieved (e.g., by incentivizing participation, or by mandating lecture attendance and penalizing absences).

We define two outcomes of interest. We first test for differences in overall course performance (measured in percent of total points received) and then assess differences in learning growth. We measure learning growth by computing the difference between the overall course performance and the first midterm scores (once more measured in percent). This metric captures the progress students made throughout the quarter after

[6]Students taking these courses must receive at least a C- in ARE 100A.

completing their first summative assessment and receiving feedback throughout. We begin our analysis with the following specification to estimate the effect of in-person attendance on students' overall performance:

$$y_{ic} = \alpha + \beta_1 attendance_{ic} + \Gamma X_i' + \mu_i$$

To estimate the effects of different attendance policies, and to test for differential effects across student populations (e.g., students participating in EOP or FG students), we run the following specification:

$$y_{ic} = \alpha + \beta_1 attendance_{ic} + \beta_2 treat1_c + \beta_3 treat2_c + \beta_4 attendance_{ic} * treat2_c + \beta_5 attendance_{ic} * EOP_i + \beta_6 attendance_{ic} * treat2_c * EOP_i + \Gamma X_i' + \mu_i$$

In these specifications, y_{ic} represents the learning outcome for student i in class c. Attendance takes on values between 0-100, and reflects the attendance or participation score assigned to each student. Students who are assigned a value of zero did not attend lectures throughout the quarter, while students receiving the maximum value of 100 attended almost all lectures.[7] Treat 1 and Treat 2 are indicator variables. Finally, in both specifications, we include a vector of students' demographics and characteristics denoted by X_i'. These include indicators of self-identified gender, race, and ethnicity, whether a student participated in the EOP program, is a transfer or international student, changed their major, as well as students' overall GPA observed during the fall 2023 quarter and grade received in ARE 100A.

We control for overall differences in teaching approach and course design (including attendance policies) by including both treatment group identifiers in our regressions. Due to the nature of our data and construction of the attendance variable, we interact attendance with only one of the treatment identifiers (treat 2) to test for differential effects in how increases in attendance are achieved, however.[8] Finally, we cluster standard errors at the student level to account for additional unobserved heterogeneity and the fact that some students are included in the analysis more than once (if they are enrolled in two or more of these courses).

Our primary coefficients of interest are the βs. We can test for significant effects of increased attendance (β_1). The interaction terms further allow testing whether it matters how increases in attendance are achieved, and whether separately identifiable student populations are affected differently by increased attendance, and by course design. We use both EOP participation and first-generation status to identify students who have

[7] Students are assigned either 0 or 100 for ARE 171 taught during the fall, based on the instructors' recollection of which students regularly attended lectures, effectively transforming this variable into a binary variable for our control. Attendance in the other courses is more precisely measured and includes a range of values.

[8] Attendance is effectively an indicator variable for our control course, taking on the value of one (regular attendance) for few (11%) of the observations four the control course. The interaction of attendance and treatment 1 is therefore highly correlated with our treat 1 indicator, and we cannot separately identify the incremental effect of increased attendance achieved by treatment 1 as compared to the control.

likely experienced a larger set of challenges than the majority of students currently enrolled in college. We prefer the use of EOP participation over FG status as it captures intersectionality between race, FG, and low-income status.

Tables 3 and 4 report results for students' overall course performance across all four classes. Column (1) presents the effects of increased lecture attendance independent of how it was achieved. We confirm findings already reported in the existing literature demonstrating that higher in-person lecture attendance is significantly and positively correlated with better academic outcomes – students who attend lectures more frequently perform better overall. Going from not attending lectures to regularly attending all lectures improves overall course performance by 13.1% on average, an effect that can move students an entire letter grade in most grading schemes. This effect is robust across specifications.

Differences in students' previous performance, measured either by GPA or grade received in ARE 100A, also significantly impact overall course performance. A (one-point) lower previous GPA reduces overall performance by 9% in these upper-level electives on average.[9] Finally, the overall performance of international and Asian students is significantly lower on average than the performance of domestic and non-Asian students (by 2-4% on average). We did not detect additional significant differences in overall course performance across self-identified gender, participation in EOP, FG status, students identifying as historically underrepresented minorities (AHN), or internal changes in major. Taken together, these initial results suggest that the difference between no and regular lecture attendance is the most pronounced determinant of the differences in overall course performance observed.

Once included in the regressions (columns 2, 3, and 4), differences in attendance policies and overall teaching approach emerge as the largest determinant of students' overall course performance, however. The results presented in column (2) indicate that increases in attendance achieved using mandatory attendance policies resulted in an increase in overall performance by only 1.8% on average. In fact, overall performance in the treatment 1 course decreased by 8.1% on average compared to the control course, although this effect is more than offset when moving from no to regular lecture attendance (i.e., an increase in overall performance by 9.9% on average). In contrast, achieving regular lecture attendance with incentivized participation (treatment 2) increases overall performance in treatment 2 by 21.8 %. Put differently, once we control for the average impact of going from no to regular lecture attendance (9.9% on average), students in the courses included treatment 2 perform significantly better (increase their overall performance by an additional 11.9% on average) compared to those in the control course. These specifications further indicate that female-identifying students perform significantly worse than their male counterparts, although these

[9] Although not reported here, the results are qualitatively the same for specifications that use the grade received in ARE 100A instead of the cumulative GPA observed in previous quarters.

average differences are relatively small (less than 2%).

Once we control for differences in student attendance and include treatment identifiers in our analysis of overall performance that capture overall differences in course design and teaching approach, we do not detect additional significant differences in performance depending on how increases in attendance were achieved (i.e., the interaction term for $Attendance * Treat2$ is not statistically significant in specifications 3 and 4). We also do not detect any additional differential effects for students who participated in EOP or for FG students compared to all other students.[10]

It is worth mentioning that these detected differences could point to differences in grading policies or difficulty level across these courses, and when viewed in isolation, one could draw the conclusion that the instructor for ARE 133 and 136 (treatment 2) was a more lenient grader. However, the statistics presented in the previous section allow us to reject this interpretation. The observed first midterm performances as well as grades submitted (mean GPA) were similar across both treatment groups, suggesting a similar level of difficulty and grading standards across all four courses. Students' comments included in the appendix provide additional suggestive evidence that the difficulty level and perceptions of the instructors are somewhat comparable.

[10] Additional regressions identifying students from different racial and ethnic backgrounds also do not show significant results. For space considerations, these are not included.

Table 3: Dependent Variable: Overall Course Performance

	(1)	(2)	(3)	(4)
Gender (1=female)	0.414	-1.778**	-1.837**	-1.889**
	(1.178)	(0.824)	(0.831)	(0.815)
Part. in EOP (1=yes)	-1.278	-1.798	-1.370	-1.882
	(1.707)	(1.973)	(1.282)	(2.031)
Int. student (1=yes)	-4.135***	-2.554***	-2.478**	-2.567***
	(1.354)	(0.979)	(0.977)	(0.979)
Transfer student (1=yes)	1.364	0.421	0.382	0.532
	(1.342)	(0.957)	(0.958)	(0.993)
Change in major (1=yes)	-0.612	-0.662	-0.646	-0.570
	(1.226)	(0.791)	(0.782)	(0.771)
GPA (Fall 2023)	9.886***	9.013***	8.984***	8.949***
	(1.744)	(1.399)	(1.402)	(1.394)
Attendance	0.131***	0.099***	0.128***	0.127***
	(0.014)	(0.017)	(0.030)	(0.031)
Treat 1		-8.057***	-10.599***	-9.747***
		(2.112)	(3.150)	(3.013)
Treat 2		11.926***	13.789***	13.839***
		(1.500)	(1.627)	(1.623)
Attendance*EOP		0.004		-0.064
		(0.023)		(0.068)
Attendance*Treat 2			-0.047	-0.050
			(0.033)	(0.033)
Attendance*Treat 2*EOP				0.086
				(0.069)
N	387	387	387	387
R^2	0.361	0.715	0.717	0.723
Degrees of Freedom	310	310	310	310
BIC	2954.22	2659.54	2657.33	2660.63

Notes: Standard errors are in parenthesis. Standard errors are clustered at student level.
* denotes significance at 0.10; ** at 0.05; and *** at 0.01.

Table 4: Dependent Variable: Overall Course Performance

	(1)	(2)	(3)	(4)
Gender (1=female)	0.707	-1.572*	-1.634**	-1.699**
	(1.155)	(0.806)	(0.807)	(0.800)
First Gen (1=yes)	-1.236	-2.053	-0.994	-2.242
	(1.155)	(1.733)	(0.778)	(1.717)
Asian (1=yes)	-2.431**	-1.759**	-1.713**	-1.667**
	(1.128)	(0.755)	(0.758)	(0.768)
AHN (1=yes)	0.496	-0.186	0.059	-0.146
	(1.780)	(1.399)	(1.391)	(1.420)
Change in major (1=yes)	-1.363	-0.937	-0.865	-0.948
	(1.113)	(0.778)	(0.778)	(0.796)
GPA (Fall 2023)	9.453***	8.802***	8.778***	8.918***
	(1.583)	(1.270)	(1.274)	(1.275)
Attendance	0.131***	0.091***	0.128***	0.122***
	(0.014)	(0.018)	(0.030)	(0.031)
Treat 1		-7.686***	-10.447***	-9.235***
		(2.196)	(3.207)	(3.096)
Treat 2		12.281***	14.387***	14.304***
		(1.565)	(1.677)	(1.685)
Attendance*First Gen		0.014		-0.016
		(0.021)		(0.034)
Attendance*Treat 2			-0.052	-0.056*
			(0.033)	(0.034)
Attendance*Treat 2*First Gen				0.045
				(0.032)
N	387	387	387	387
R^2	0.354	0.714	0.716	0.720
Degrees of Freedom	310	310	310	310
BIC	2957.90	2660.75	2658.54	2664.98

Notes: Standard errors are in parenthesis. Standard errors are clustered at student level.
* denotes significance at 0.10; ** at 0.05; and *** at 0.01.

Table 5: Dependent Variable: Learning Growth (Course Overall - Midterm1)

	(1)	(2)	(3)	(4)
Gender (1=female)	2.354	-0.407	-0.471	-0.468
	(1.478)	(0.968)	(0.973)	(0.959)
Part. in EOP (1=yes)	2.145	-2.106	1.719	-2.464
	(2.087)	(2.092)	(1.435)	(2.124)
Int. student (1=yes)	1.866	3.787***	3.875***	3.632***
	(1.798)	(1.193)	(1.191)	(1.194)
Transfer student (1=yes)	2.308	1.097	1.088	1.343
	(1.705)	(1.169)	(1.179)	(1.184)
Change in major (1=yes)	0.958	0.989	0.903	1.082
	(1.467)	(0.992)	(0.992)	(0.999)
GPA (Fall 2023)	-1.155	-2.308**	-2.330**	-2.351**
	(1.545)	(0.967)	(0.966)	(0.943)
Attendance	0.065***	0.025	0.016	0.008
	(0.016)	(0.016)	(0.023)	(0.024)
Treat 1		-11.605***	-10.077***	-8.871***
		(2.183)	(2.385)	(2.313)
Treat 2		14.295***	13.378***	13.356***
		(1.449)	(2.025)	(2.032)
Attendance*EOP		0.052**		-0.052
		(0.024)		(0.058)
Attendance*Treat 2			0.027	0.021
			(0.028)	(0.028)
Attendance*Treat 2*EOP				0.132**
				(0.061)
N	387	387	387	387
R^2	0.047	0.573	0.571	0.586
Degrees of Freedom	310	310	310	310
BIC	3153.71	2860.75	2862.89	2860.32

Notes: Standard errors are in parenthesis. Standard errors are clustered at student level.
* denotes significance at 0.10; ** at 0.05; and *** at 0.01.

Table 6: Dependent Variable: Learning Growth (Course Overall - Midterm1)

	(1)	(2)	(3)	(4)
Gender (1=female)	1.903	-1.065	-1.064	-1.194
	(1.435)	(0.942)	(0.942)	(0.937)
First Gen (1=yes)	0.971	-2.022	1.212	-2.406
	(1.498)	(2.117)	(1.004)	(2.134)
Asian (1=yes)	2.132	3.038***	3.084***	3.163***
	(1.528)	(0.971)	(0.989)	(0.985)
AHN (1=yes)	1.651	0.548	0.797	0.266
	(2.290)	(1.574)	(1.579)	(1.557)
Change of major (1=yes)	-0.054	0.512	0.546	0.352
	(1.408)	(0.919)	(0.930)	(0.927)
GPA (Fall 2023)	-1.212	-2.098**	-2.203**	-1.876**
	(1.458)	(0.920)	(0.913)	(0.921)
Attendance	0.066***	0.023	0.019	0.002
	(0.016)	(0.019)	(0.021)	(0.023)
Treat 1		-12.573***	-10.610***	-8.162***
		(2.164)	(2.191)	(2.289)
Treat 2		13.594***	12.566***	12.363***
		(1.452)	(2.094)	(2.090)
Attendance*First Gen		0.046*		-0.020
		(0.026)		(0.037)
Attendance*Treat 2			0.032	0.022
			(0.027)	(0.027)
Attendance*Treat 2*First Gen				0.096***
				(0.034)
N	387	387	387	387
R^2	0.045	0.573	0.570	0.588
Degrees of Freedom	310	310	310	310
BIC	3154.60	2860.98	2863.83	2859.34

Notes: Standard errors are in parenthesis. Standard errors are clustered at student level.
* denotes significance at 0.10; ** at 0.05; and *** at 0.01.

To analyze differences in learning outcomes and more closely tie observed student performance to learning growth, we run the same regression specifications using improvements in student performance observed over the entire quarter as the dependent variable. Tables 5 and 6 present these regression results. Specification 1 measures the effect of increased attendance, regardless of how it is achieved, and suggests that regularly attending lectures (compared to not attending lectures) results in an improvement in overall course performance by 6.5% on average. Apart from this significant contribution to learning growth, we do not find additional differences due to socio-demographic differences, prior performance, or preparedness. Once we allow for differences in how lecture attendance is achieved, the impact of increased lecture attendance is reduced and becomes insignificant (see specification 3). This might at least partially be a result of the overall increase in lecture attendance picked up by both treatment indicators.

Rather than contributing to improvements, the implementation of the mandatory attendance policy (treatment 1) reduces observed improvements by 11% on average or inhibits learning growth compared to teaching with no attendance policies in place. In contrast, incentivized participation (treatment 2) contributes significantly to improvements or learning growth (by 14.3% on average). Specifications 2-4 further suggest that international and Asian students improve their performance relatively more than domestic, non-Asian students, and students with a higher GPA improve their performance by relatively less than students with a lower GPA. Finally, EOP and FG students who regularly attend lectures improve their performance significantly more than all other students (by 12-13% on average), and this effect is more pronounced for the courses in treatment 2 (as captured by the triple interaction between attendance, treat 2, and EOP)).[11]

These results suggest that although mandatory attendance can bring a large number of students back to the classroom, and increased lecture attendance can improve overall performance, a teaching approach that instead incentivizes participation might offer additional benefits. These include relatively stronger overall performance, significant average improvements in learning growth, as well as relatively greater improvements for vulnerable student populations. As such, our regression results reported here suggest that the means by which increases in lecture attendance are achieved matter and could contribute to course-specific learning growth for all students. Our results also suggest that student-centered and inclusive teaching approaches can contribute to closing achievement gaps.

Finally, we take a closer look at a small subset of students who were enrolled in more than one of these courses. Our sample includes nine students who repeated ARE 171 in the spring quarter. These students took ARE 171 with and without mandatory attendance policies in place. We observed close to perfect attendance when these students retook this course in the spring quarter, and an increase in their overall course

[11] In addition to the regressions reported here, we also ran quantile regressions. We obtained qualitatively similar results for all quantiles, with the most pronounced differences detected for the lowest quantile.

performance ranging from 1.5% to 31%, amounting to a mean increase of 11.6%. This increase is slightly lower than the average increase in overall course performance across all courses reported in specification 1 of Table 3. However, we do not detect learning growth for any of these students as their overall course performance is lower than their performance on the first midterm. An additional 38 students were enrolled in ARE 171 (treat 1) and either ARE 133 or 136, or both (treat 2). For 76% of these students, we observed positive learning growth in treatment 2 courses but negative growth in the control or treatment 1 courses. These observed differences further support our interpretation of our regression results and further suggest that the means by which higher lecture attendance is achieved matter.

4 Students' Belonging & Learning in Classrooms

Our survey design recognizes that students' course-specific sense of social belonging can vary significantly based on differences in students' identities, prior experiences, beliefs, status-quo bias, and generalizations based on negative stereotypes. In turn, these factors might affect learning outcomes. Existing research conducted primarily in other STEM disciplines already documents strong associations between students' sense of belonging and learning outcomes (Bayer et al., 2020; Edwards, Barthelemy, and Frey, 2021; Edwards et al., 2022). These studies find strong correlations between social belonging and belonging uncertainty, student academic performance, and retention within STEM disciplines. Gopalan and Brady (2020) further documents that students' sense of belonging is positively correlated with their resilience or persistence, engagement level, and overall mental health.

What is less well understood is the direction of these effects or whether students' course-specific sense of belonging results from feedback received, and how students form and update beliefs about their relative academic ability. While some students might feel that they belong independent of the feedback received and their relative performance in a course, for others, instructor and peer feedback might significantly influence their sense of belonging and beliefs regarding their ability. Our survey attempts to capture these complexities by asking students about their course-specific learning experiences, sense of belonging, and belonging uncertainty, both independent of feedback received and conditional on positive or negative feedback regarding their performance received (e.g., whether they performed or didn't perform well).

The survey was sent out to all students enrolled in at least one of the four courses included in our analysis.[12] The survey consists of statements that students rated on a seven-point Likert scale, where 1 indicated "strongly disagree" and 7 indicated "strongly agree" and allowed students to submit additional

[12] As previously mentioned, the survey was distributed at the end of the spring quarter. This meant that students enrolled in ARE 171 during the fall quarter received the survey almost two quarters after they completed the course. Consequently, we observe significantly lower response rates for this course compared to the courses taught in spring (see Table 1).

feedback or comments they wanted to share. Here, we analyze responses to the following statements:

a) "Setting aside my performance in class, I felt like I belong."

b) "I felt uncertain about my belonging (i.e., sometimes I feel that I belong and sometimes I did not)."

c) "When I didn't perform well in this course, I felt like maybe I didn't belong."

d) "When I performed well in this course, I felt like maybe I did belong."

Similarly, students were asked to rate the following statements describing their sense of belonging:

a) "Setting aside my performance in this class, I feel like I learned a lot."

b) "I felt uncertain about my learning."

c) "Whenever I didn't perform well in this course, I felt like maybe I am not learning anything."

d) "When I performed well in this course, I felt like maybe I am learning a lot.[13]

Below, we graph students' self-reported measures of unconditional and conditional (depending on feedback received) sense of belonging and learning experience. We begin by summarizing differences in survey responses across our defined treatment groups in figure 2.[14] No clear pattern emerges when analyzing course-specific sense of belonging and belonging uncertainty. However, we find that students enrolled in courses defined as treatment 2 are relatively more accepting of negative or critical feedback and are less dependent in their sense of belonging on positive feedback, as indicated in panels 3 and 4. Especially when looking at panel 3, a larger share of students in treatment 2 (incentivized attendance) strongly disagree or disagree that they feel they belong less after receiving negative feedback, while a larger share of students in treatment 1 strongly agree or agree. Students in treatment 1 also strongly disagree or disagree that they learned relatively less when they received negative feedback, while students in treatment 2 are more likely to view this feedback received as indicative of what they learned (panel 7).

Figure 3 reports survey responses broken down by self-identified gender (across all four courses), depicting pronounced differences and consistent patterns for both sense of belonging and learning experiences. Students identifying as female generally report a stronger sense of social belonging than students identifying as male (panel 1). However, they are also significantly more likely to feel uncertain about their belonging than male students (panel 2) and are more sensitive to both negative and positive feedback received than students identifying as male (panel 3 and 4). Importantly, significantly more female-identifying students than male-identifying students report that not performing well adversely affects their sense of belonging, while receiving positive feedback regarding their performance enhances it. We observe similar patterns in students' self-reported learning experiences.

[13] The complete survey is included in the appendix.

[14] Due to the significantly lower response rates for ARE 171 taught during the fall, we do not include these survey responses in our analysis.

Figure 2: Survey Responses across Treatments

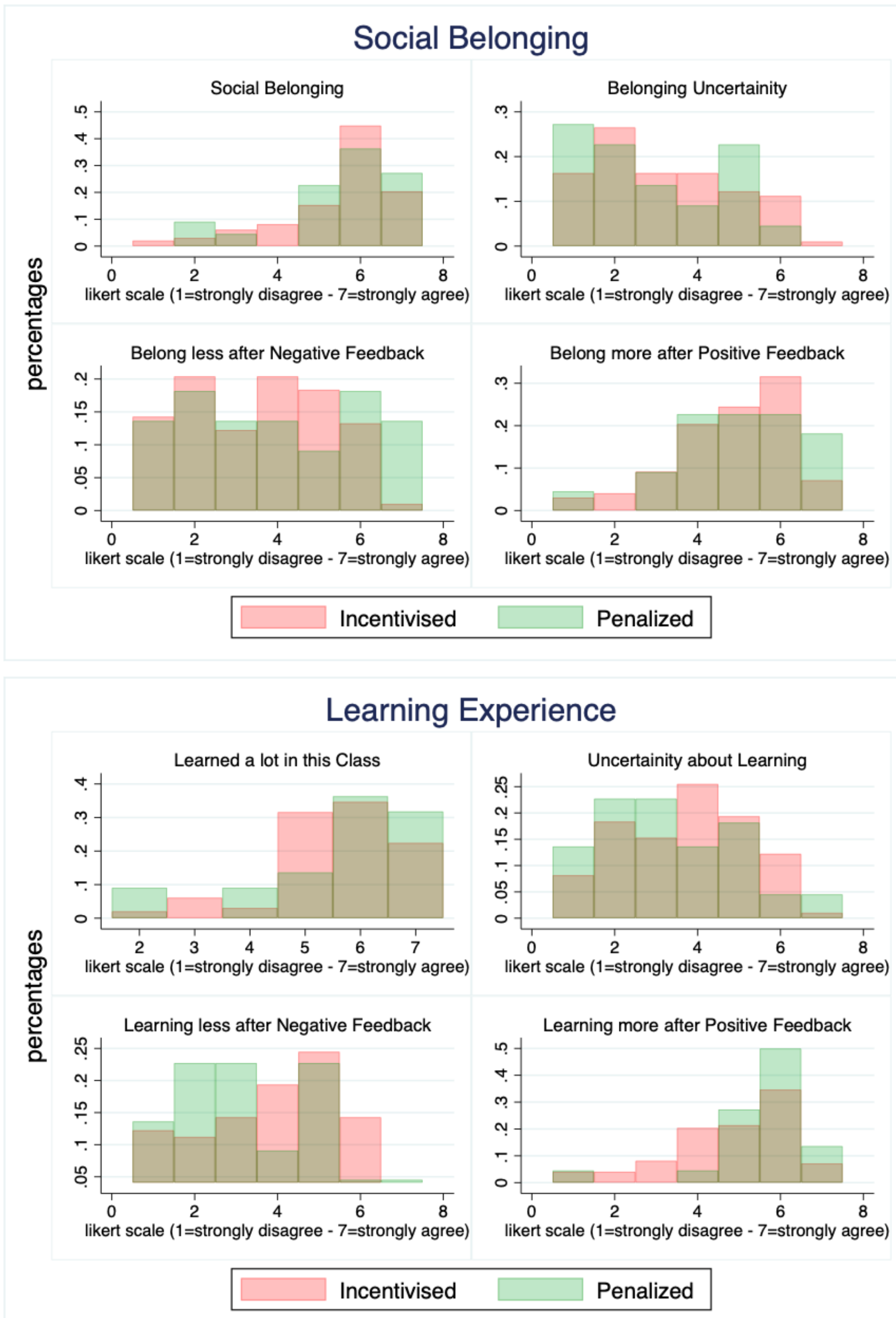


Figure 3: Survey Responses by Gender

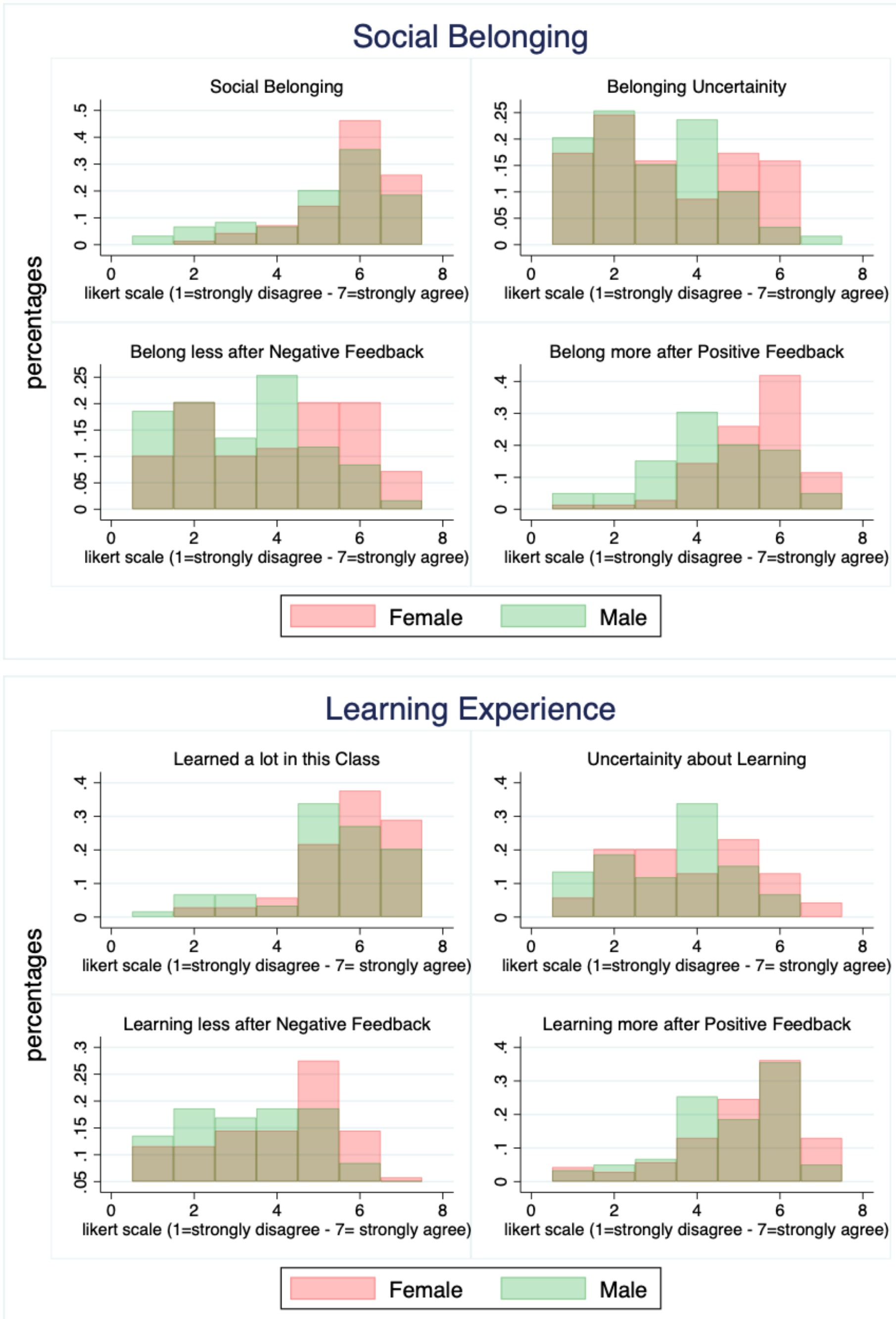


Figure 4: Survey Responses by Ethnicity

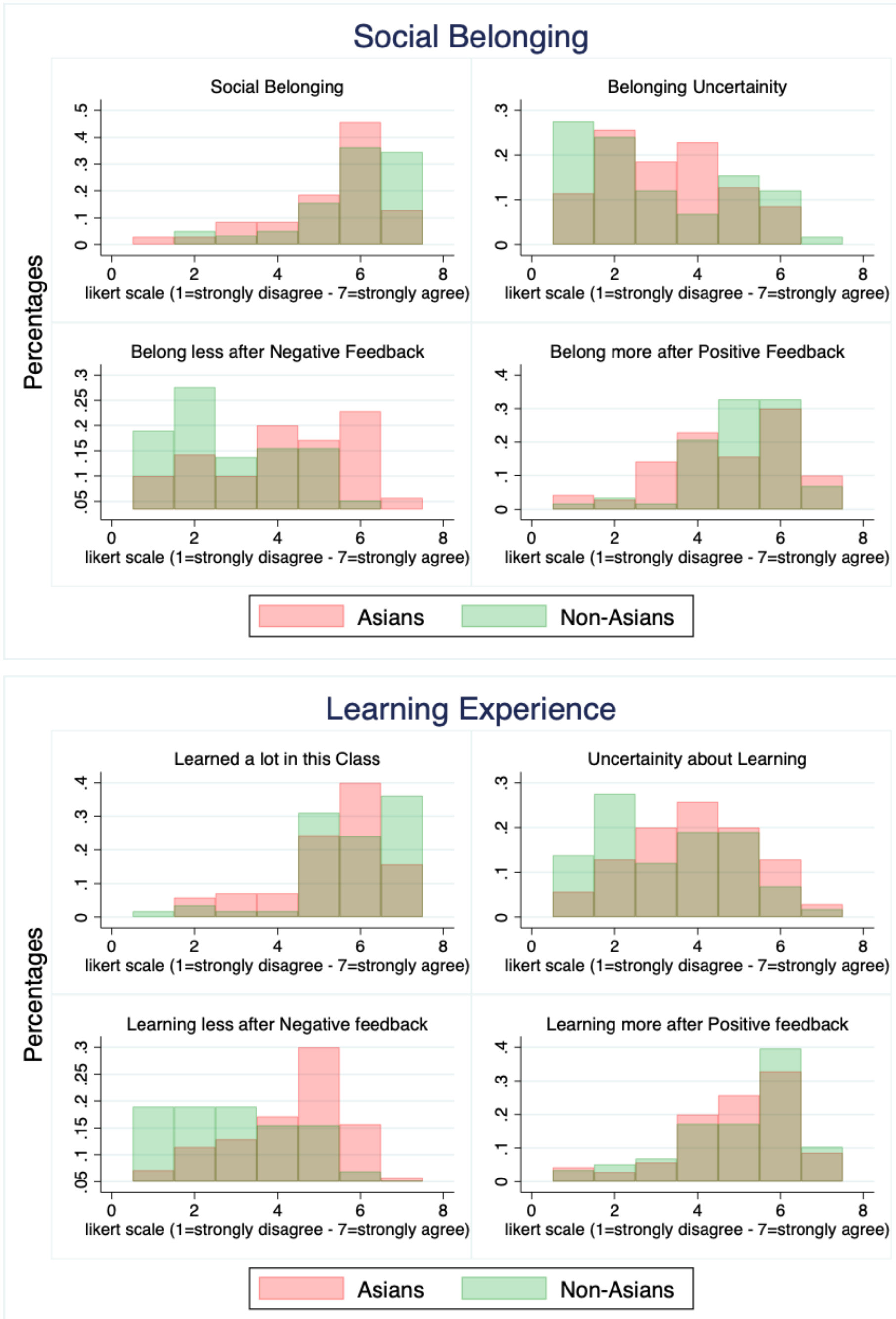


Figure 4 depicts sense of belonging and learning experiences across self-reported race and ethnicity, intended to capture students' diverse cultural backgrounds. We compare students identifying as Asian (both domestic and international students) with students from all other racial/ethnic backgrounds. Although we do not observe a clear pattern for social belonging in general, we find that Asian students feel more strongly (in either direction) about belonging uncertainty than non-Asian students. Similar to our detected gender differences, Asian students are also more vulnerable or responsive to feedback received than non-Asian students. We once more replicate this pronounced pattern when looking at learning experiences. It is worth mentioning that 34% of Asian students are international students. These students may have difficulties in adjusting to a new cultural environment and other associated pressures. A strong emphasis on academic achievements within Asian culture, whether students grew up in the US or not, could further explain the relatively stronger response to feedback and grades received.[15]

Taken together, we interpret the patterns we detected as suggestive of differences in student experiences and sense of belonging along several dimensions (including teaching approach chosen by the instructor), that likely interact with each other. While the existing literature documents differences in the sense of belonging by gender, especially in STEM disciplines (Bayer et al., 2020), the significant differences for Asian compared to non-Asian students are not currently reported to our knowledge. Importantly, Asian students are not an underrepresented minority in these courses, but still differ significantly in their sense of belonging and learning experiences from White or Caucasian students, the largest subgroup of non-Asian students used as a comparison group.

5 Conclusion

The new and existing challenges experienced in the aftermath of the COVID-19 pandemic motivate a continued search for practical solutions that can strengthen academic excellence. One frequently discussed challenge in this context is how to bring students who have experienced the flexibility and convenience of online learning and have access to AI tools back to the classroom.

Reduced lecture attendance and overall student engagement in Agricultural Economics and Agribusiness undergraduate programs affect our ability to attract students to our discipline and related careers, and likely exacerbate the growing gap between industry demands and students' expressed interests. While technological advances may reduce the demand for seasonal labor (Martin, 2023), the tremendous demand for well-trained college graduates who can manage innovations and tackle pressing environmental, health, and equity concerns along the agricultural supply chain and in food access decisions is less often acknowledged (CDFA, 2023; Ratliff et al., 2025). This paper contributes to a broader discussion of how to attract and better prepare new talent for successful careers in the agricultural and food industry, government, and academia by providing evidence-based and data-driven solutions that can support students' individual and collective learning.

Our results suggest that both mandatory attendance policies and incentivized participation significantly

[15] We cannot test for distinct patterns for AHN and non-AHN student populations, first-generation and non-first-generation students, and students who are and are not participating in EOP as we have fewer observations for these pairwise comparisons than for the ones reported here. We are currently collecting additional data to increase our sample size and hope to expand our analyses in future research publications.

increase lecture attendance, and that increased attendance improves students' course-specific academic outcomes. Neither approach relied on banning or purposely limiting the use of technology (e.g., disabling lecture capture to incentivize students to attend lectures), and both approaches allow for occasional absences. However, we argue that our findings suggest that the adoption of student-centered and inclusive teaching approaches that use a carrot rather than a stick approach (incentivize participation and emphasize learning growth rather than penalize absences) might lead to additional gains and further improve educational outcomes. Importantly, we detect significant differences in learning growth that could help close existing achievement gaps.

Our findings suggest that students' diverse identities and backgrounds significantly impact their course-specific sense of belonging and learning experiences. Here, too, a commitment to student-centered teaching approaches and course designs that incentivize participation rather than penalize absences could provide additional benefits and allow students to improve their resilience, responsiveness to feedback, and overall confidence in their abilities.

Data generated by randomized controlled trials or studies that analyze natural experiments are rare when analyzing the effectiveness of different teaching approaches or educational policies. Although we argue that we leverage a quasi-natural experiment, we cannot control for all possible interactions between course design, student characteristics, instructor characteristics, and lecture times, nor can we test for possible underlying mechanisms generating the observed differences in learning growth. While more research is needed to check the robustness of the results and interpretations presented here, we hope that our analysis and discussion provide practical suggestions for teaching and advance pedagogy research.

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