36-627 Project Report

Due: April 24, 2026 at 5:00 PM

Dominick Robinson

Introduction

Cranberry Melon University's growing enrollment has created a shortage of large lecture halls. To optimize facility use, the administration is considering scheduling more courses at 8:00 AM. However, existing research suggests a link between early start times, sleep deprivation, and diminished cognitive performance.

This study investigated whether 8:00 AM scheduling significantly harms student GPAs and sleep duration, and whether these effects disproportionately impact specific race or gender groups."

To answer these questions, we conducted a Completely Balanced 2^5 Factorial Design involving 384 students. The sample was distributed equally across all 32 treatment combinations of race, gender, academic year, instructor, and course time. We then conducted cascaded ANCOVA tests to first investigate whether the relationship of course time on sleep and term GPA varies by race and/or gender, and then testing whether course time affects sleep and term GPA in general. The total cost of the experiment is $\$115,200$, which includes a \$200 participation reward and \$100 Fitbit for each student.

After conducting the experiment, we found no statistically significant evidence that early morning class times cause disproportionate harm to certain gender or race groups. However, we found statistically significant evidence that early morning class times do have negative effects on student sleep time and academic performance.

Methods

Experimental Design and Data Collection

To evaluate the impact of 8:00 AM scheduling, we conducted a completely balanced 2^5 factorial design experiment involving 384 students at Cranberry Melon University. The participants were recruited to represent a balanced cross-section of the student body. Each student was assigned to a specific course section and provided with a wearable Fitbit device to objectively track total sleep time throughout the semester.

Our design includes five factors, each at two levels:

- Treatment: Course Time (8:00 AM vs. 1:30 PM)
- Blocking Factors: Race (Underrepresented vs. Non-Underrepresented), Gender (Male vs. Female), Academic Year (Freshman vs. Sophomore), and Instructor (Instructor A vs. Instructor B)

Table 1 shows that our experiment is indeed balanced across these five factors.

Table 1: Student counts per demographic and treatment combination, confirming perfect balance across the 32 experimental cells.

Race	Gender	Year	8:00 AM (Morning)	1:30 PM (Afternoon)
Non-Underrepresented	Female	Freshman	24	24
Non-Underrepresented	Female	Sophomore	24	24
Non-Underrepresented	Male	Freshman	24	24
Non-Underrepresented	Male	Sophomore	24	24
Underrepresented	Female	Freshman	24	24
Underrepresented	Female	Sophomore	24	24
Underrepresented	Male	Freshman	24	24
Underrepresented	Male	Sophomore	24	24

Sample Size and Power Analysis

The sample size of $N = 384$ was determined via a power analysis based on residual variance estimates from a pilot study (CMU Statistics Data Repository, 2026). This recruitment level was specifically chosen to provide sufficient statistical power (>99%) to detect a 0.20 point drop in term GPA and a 30-minute reduction in total sleep time for general treatment effects. While detecting demographic interactions is statistically more demanding, this sample size provides approximately 72% power for GPA-race interactions and 82% power for sleep-race interactions. While the 72% is lower than the recommend 80% minimum power, this is the best we could do given our cost and sample size limitations.

The primary analysis was conducted using Analysis of Covariance (ANCOVA). While the design was balanced through blocking, we identified "Cumulative GPA" as a critical baseline covariate. Preliminary Exploratory Data Analysis (EDA) confirmed a strong linear relationship between a student's prior cumulative GPA and their performance during the semester.

Analysis

Our analysis follows a cascaded modeling approach.

First, we fit the following models to test for disproportionate harm based on demographic factors (race and gender):

$$\begin{aligned}\text{Model 1 (GPA):} \quad Y_{GPA} &= \beta_0 + \beta_1 X_{CumGPA} + \tau_{Time} + \theta_{Race} + \theta_{Gender} + \theta_{Year} + \theta_{Inst} \\ &\quad + (\tau\theta)_{Time\times Race} + (\tau\theta)_{Time\times Gender} + \epsilon\end{aligned}$$

$$\begin{aligned}\text{Model 2 (Sleep):} \quad Y_{Sleep} &= \beta_0 + \beta_1 X_{CumGPA} + \tau_{Time} + \theta_{Race} + \theta_{Gender} + \theta_{Year} + \theta_{Inst} \\ &\quad + (\tau\theta)_{Time\times Race} + (\tau\theta)_{Time\times Gender} + \epsilon\end{aligned}$$

and we tested the following hypotheses:

$$\begin{aligned}H_0 &: (\tau\theta)_{Time\times Race} = 0 \quad \text{(The effect of 8am classes is the same across all races.)} \\ H_a &: (\tau\theta)_{Time\times Race} \neq 0 \quad \text{(8am classes disproportionately affect students of certain races.)}\end{aligned}$$

$H_0 : (\tau\theta)_{Time \times Gender} = 0$ (The effect of 8am classes is the same across all genders.)
$H_a : (\tau\theta)_{Time \times Gender} \neq 0$ (8am classes disproportionately affect students of certain genders.)

If the interaction terms above are not significant, we simplify the model and test the main effect of Time (τ_{Time}).

$H_0 : \tau_{Time} = 0$ (Holding a class at 8am has no significant effect on the outcome.)
$H_a : \tau_{Time} \neq 0$ (Holding a class at 8am significantly changes the outcome.)

"Cumulative GPA" was included in the "Sleep" models as a proxy to attempt to control for student behavior, such as organizational and time management skills.

Diagnostics

Prior to interpreting the results, we performed standard diagnostic checks on all linear models. We utilized Residuals vs. Fitted plots to verify homoscedasticity and normal Q-Q plots to confirm the normality of error terms. Furthermore, performed residual analysis to ensure that there were no leverage or influential points significantly biasing our results. Finally, we checked the distribution of cumulative GPA across class times to verify that cumulative GPA and class time are not aliased, which would reduce our ability to separate the effects of each covariate on term GPA.

Results

Demographic Equitability of Effects of Class Time on Sleep and GPA

Table 2: Analysis of demographic equity: Testing for disproportionate harm by race and gender.

Outcome	Interaction	p.value
Term GPA	Time x Race	0.908
Term GPA	Time x Gender	0.564
Sleep Duration	Time x Race	0.243
Sleep Duration	Time x Gender	0.639

To address concerns regarding demographic equity, we tested for interaction effects between course timing and student background. The analysis indicated that the negative impact of 8:00 AM classes on term GPA did not significantly differ by race, $p = 0.908$, or by gender, $p = 0.564$.

Similarly, the reduction in sleep duration was found to be consistent across demographic groups, with no significant interaction observed for race, $p = 0.243$, or gender, $p = 0.639$. These results suggest that early start time does not disproportionately disadvantage any specific demographic group analyzed in this study.

Main Effects of Class Time on Sleep and GPA

Table 3: General impact of 8:00 AM scheduling on student GPA and sleep duration.

Outcome	Estimate	Std.Error	p-value
Term GPA	-0.127	0.038	0.001
Total Sleep Time	-17.768	4.987	0.000

Our analysis revealed a significant negative effect of 8:00 AM course scheduling on academic performance. After controlling for baseline cumulative GPA and instructor, students in the morning sections earned significantly lower term GPAs than those in afternoon sections, $\tau_{\text{Time}} = -0.13$, 95% CI $[-0.2, -0.05]$, $p = 0.001$.

A similar trend was observed for student wellness. Students assigned to 8:00 AM sections experienced a substantial reduction in average nightly sleep compared to their peers in later sections, $\tau_{\text{Time}} = -17.8$ minutes, 95% CI $[-27.6, -8]$, $p < .001$.

Diagnostics

All linear modeling assumptions were verified via residual analysis, as seen in Figure 1.

Additionally, as shown in Figure 2, the distribution is approximately equal within each group, eliminating any concerns of aliasing between cumulative GPA and class time that could limit our ability to detect the effect of time on term GPA.

Discussion

The results of this experiment suggest that while early morning classes do not disproportionately effect particular race or gender groups, they do have a statistically significant negative effect on student sleep and academic performance (measured by term GPA). Our findings indicate that 8:00 AM classes significantly harm student performance, resulting in an average GPA drop of -0.13 points and a sleep deficit of -17.8 minutes per night. We recommend that Cranberry Melon University look into alternative methods to accommodate all of the large classes, including adding evening classes rather than morning classes to better align with student sleep schedules, or even building new academic buildings with large lecture halls (if financially and logistically feasible).

Limitations include the absence of data on student commute times and employment status, which may further exacerbate the impact of early start times. Furthermore, our power to detect GPA-race interactions was 72% (slightly below the 80% target). However, the extremely high p-values observed suggest a genuine lack of demographic disparity rather than a lack of statistical sensitivity.

Future research should also investigate whether these effects vary by academic discipline. For instance, students in STEM majors may face a double penalty due to higher screen-time requirements for coursework, which is independently associated with reduced sleep quality due to blue light exposure. Identifying whether specific majors are more vulnerable to early start times could allow for more targeted departmental scheduling.

In conclusion, the administration should reconsider the 8:00 AM policy to protect student wellness and academic achievement.

References

CMU Statistics Data Repository. (2026). *Sleep habits and GPA observational study.* Retrieved from https://cmustatistics.github.io/data-repository/psychology/cmu-sleep.html

Appendix

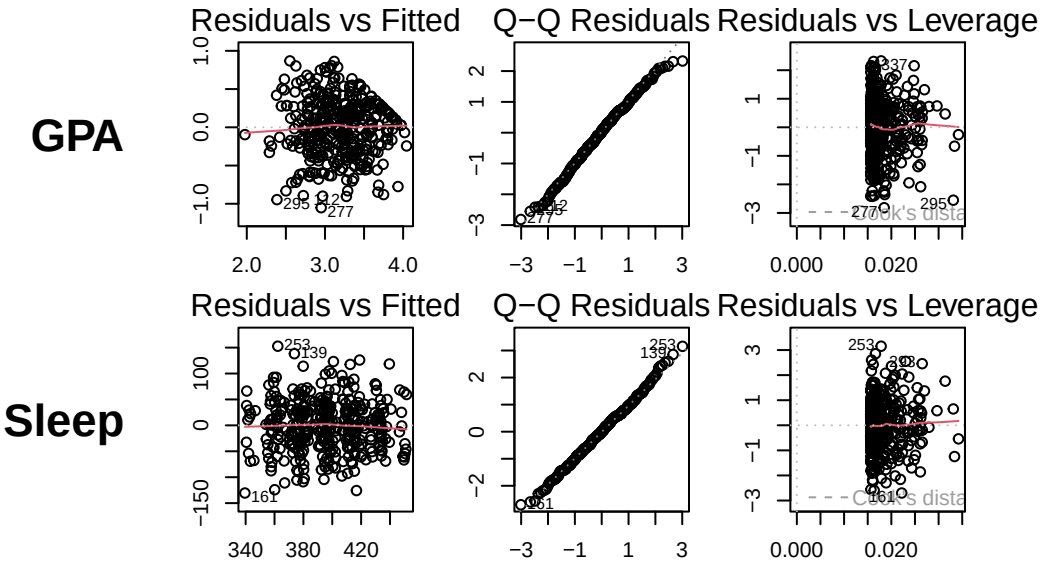

Figure 1: Diagnostic plots for main effect models. The residuals seem homoskedastic and normally distributed, and there are no leverage or influential points, so all modeling assumptions appear to be met for both models.

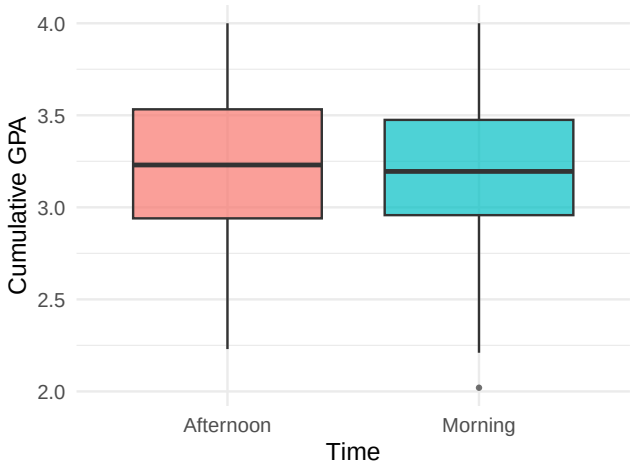

Figure 2: Distribution of cumulative GPA by class time. The distribution is approximately equal within each group, eliminating any concerns of aliasing between cumulative GPA and class time that could limit our ability to detect the effect of time on term GPA.