The Effect of Breaks on Student Productivity: Evidence from Physical Education

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Abstract

A growing body of literature suggests that the timing of student learning can be an important determinant of student success, with students performing better in morning classes rather than afternoon classes. We explore how the timing of physical education (PE) classes during the school day may be used to boost student productivity when schools are faced with constraints which limit their ability to place all students in core academic subjects in the mornings. PE causes a break from academic learning. This can be disruptive if students are actively engaged but it can also help fatigued students rebound. We develop a simple theoretical model of these competing effects that predicts that the disruptive effect dominates in the morning and the rebounding effect dominates in the afternoon. Using data from 2003-2012 on student schedules and learning outcomes from a large school district in a state that requires 400 minutes of PE every ten days for students in the sixth through eighth grades, we provide evidence that the timing of breaks matters differentially throughout the day as suggested by the theory for a composite math test given at the end of the year. There is less clear evidence that a break caused by PE matters for English tests.

Research Questions

- Does the break from classroom learning caused by PE affect student learning?
- Does the effect depend on when the break occurs during the day?

Theory

- Ability to learn depends on time spent in active classroom learning

$$A(t) = A[e(t), f(t)]$$

- e(t) represents being engaged in learning

$$\frac{\partial A}{\partial e} > 0$$

$$e'(t) > 0 \text{ and } e''(t) < 0$$

- f(t) represents fatigue

$$\frac{\partial A}{\partial f} < 0$$

$$f'(t) > 0 \text{ and } f''(t) > 0$$

- Assuming e(t) and f(t) are additively separable, the marginal ability to learn as a function of time is

$$\frac{dA(t)}{dt} = \underbrace{\frac{\partial A(t)}{\partial e(t)}}_{\text{positive}} * \underbrace{\frac{de(t)}{dt}}_{\text{decreasing}} + \underbrace{\frac{\partial A(t)}{\partial f(t)}}_{\text{negative}} * \underbrace{\frac{df(t)}{dt}}_{\textit{increasing}}$$

- $A(t)$ is concave
- Students perform better in the morning than the afternoon (Pope 2016)

Implication for Breaks

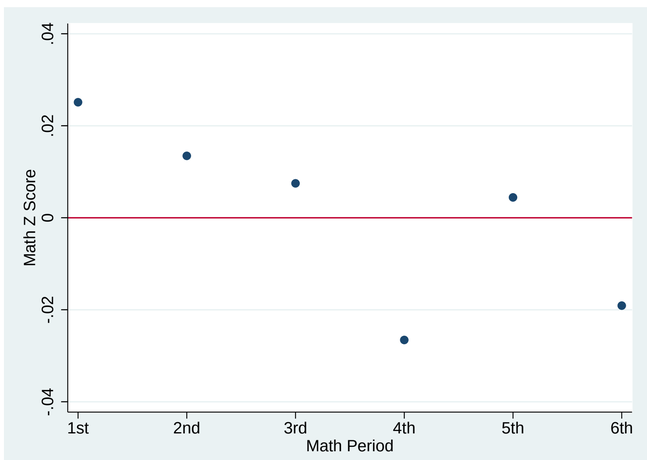
- PE removes students from active classroom learning
- Disruption effect (Csikszentmihalyi 1990)
  - Students would do better early in the day *without* the break
- Rebounding effect (Pellegrini et al. 1995)
  - Breaks combat cognitive fatigue
  - Students perform better later in the day with a break

Data

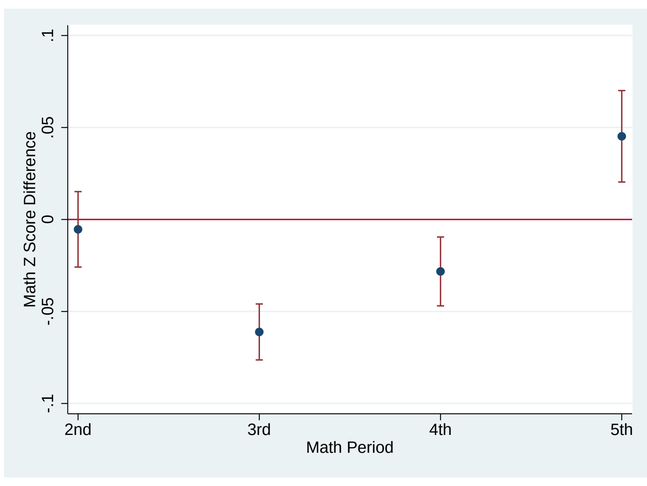
- Los Angeles Unified School District from 2003-2012
- Students in middle schools, grades 6-8
- Complete class schedule
  - Students take math, English, science, social science, PE and an elective
  - Know if PE is before or after testing class period
- CST test scores in Math and English
  - Calculate Z scores at year-test level
- Demographic Characteristics
- Drop
  - Charter schools
  - Students with more or fewer than six periods
  - Students who change schools mid-year
  - Students with multiple Math, PE, or English classes
  - Students whose course schedule changes mid-year
- Rely on randomness inherent in setting class schedules on the placement of PE relative to testing classes

Visual Evidence

Math Z scores decline over the day



Average difference in raw Z score for PE before compared to after Math by period



Empirical Specification

$$Z_{icst} = \beta_1 \text{Before}_{icst} + \beta_2 \text{Prior}_{icst} + \eta X_{it} + \lambda_{cst} + \varepsilon_{icst}$$

- Student i in course c in school s in year t
- Group all PE periods after math class together
- Distinguish PE immediately **prior** to math from all other periods **before** math
- X is student demographics
  - Gender, race/ethnicity, parent education, ELL status, NSLP status, cumulative GPA, grade level
- λ_{cst} is a course title by school by year fixed effect
- Not enough variation across all possible PE periods to include a classroom fixed effect
- Run separate regressions for math periods two through five
  - No PE classes before first period or after sixth period

Regression Results

	Math Period			
	2nd	3rd	4th	5th
Before		-0.014	-0.014	0.016
		(0.013)	(0.014)	(0.016)
Prior	0.013	-0.030**	-0.004	0.041**
	(0.013)	(0.014)	(0.016)	(0.018)
N	52,542	68,204	51,147	59,729

** p < 0.05

- Students perform *worse* in third period math when PE is in second period
- Students perform *better* in fifth period math when PE is in fourth period
- Looking at the average effect masks important heterogeneity.

Heterogeneity Results

Low-ability and High-ability students

- High-ability students get into the flow (Csikszentmihalyi 1990)
  - More harmful to remove them from active learning at this point
- Split sample by median GPA at school-year level

	Math Period			
	2nd	3rd	4th	5th
	Above Median GPA			
Before		-0.000	-0.017	0.031
		(0.018)	(0.019)	(0.021)
Prior	0.024	-0.039**	-0.016	0.037
	(0.017)	(0.018)	(0.022)	(0.024)
	Below Median GPA			
Before		-0.018	0.013	0.021
		(0.015)	(0.016)	(0.019)
Prior	-0.004	-0.021	0.017	0.051**
	(0.015)	(0.015)	(0.018)	(0.021)

** p < 0.05

Results by grade level

- "Grit" increases with age (Peña and Duckworth 2018)
  - Perseverance of effort despite struggle
  - Students' ability to learn increases as they age

	Math Period			
	2nd	3rd	4th	5th
	6th Grade			
Before		-0.056	-0.093	0.138*
		(0.043)	(0.058)	(0.072)
Prior	-0.046	-0.080*	-0.070	0.225***
	(0.069)	(0.044)	(0.081)	(0.080)
	7th Grade			
Before		-0.030	-0.014	0.004
		(0.020)	(0.021)	(0.024)
Prior	-0.023	-0.032	-0.004	0.021
	(0.020)	(0.021)	(0.024)	(0.025)
	8th Grade			
Before		-0.001	0.008	-0.008
		(0.017)	(0.019)	(0.021)
Prior	0.042**	-0.007	0.017	0.006
	(0.017)	(0.016)	(0.022)	(0.025)

* p < 0.10, ** p < 0.05, *** p < 0.01

Discussion

- Rearranging schedules is a **costless** way to increase learning and test scores
- Spillover effects
  - Students are affected by their peers' PE placement relative to math as well
  - Students less likely to get a bad cooperation mark if PE before fifth period math
  - Students perform worse in third period math when their teacher has their prep period in second period
- We do not find similar evidence for English classes and PE placement