Dealing with Student Heterogeneity: Curriculum Implementation Strategies and Student Achievement

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Motivation

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Teaching could be more effective in homogeneous classes

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- Teachers choose how to allocate their time among different pupils
  - Some of them target their lessons towards the top students
  - Others focus on the bottom segment of the class

Teaching could be more effective in homogeneous classes

- Teachers can structure the lessons for a narrower range of students

What we do

Three strategies in implementing the curriculum

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2. Moving on to another topic even if part of the class did not understand the previous one (T2)
3. Spending time to revise concepts and topics already studied in the previous year (T3)

Related literature

- Teachers' overall effectiveness:
  - Rockoff (2004)
  - Rivkin *et al.* (2005)
  - Aaronson *et al.* (2007)
- Teachers' traits (i.e. gender, age, race, experience, certification):
  - Dee (2005, 2007)
  - Kane *et al.* (2008)
  - Clotfelter *et al.* (2010)
- Teaching practices (i.e. frontal lecturing, interactive lessons, problem solving):
  - Aslam and Kingdon (2011)
  - Schwerdt and Wuppermann (2011)
  - Lavy (2011)

Preview of the results

- T1: Spending time on the same topic until everyone understands
  - No benefits for low achievers
  - Negative effect on the top classmates
- T2: Moving on to another topic even if part of the class didn't understand the previous one
  - Negative effect for every student
- T3: Spending time to revise concepts and topics already studied in the previous year
  - Positive effect on low achievers

The Data

INVALSI: universe of primary and lower-secondary students in the academic year 2009-10

- We focus on 6^{th} graders only
- Both the reading and the mathematics competencies are tested
- Test scores standardized within each subject
- We carry out the analysis on a restricted sample for which we have information on test scores in both subjects
- Final sample: more than 352,000 students,15,397 classes and 4,937 schools

Data - curriculum implementation strategies

Students' answers from a very rich questionnaire

- Students are asked to report how often a teacher of a given subject:
  - remains on the same topic as long as everyone understands
  - moves on to the next topic even if not all students understood the previous one
  - spends time to revise topics studied in the previous year
- We treat these variables as cardinal by assigning them proportional values: never=0, rarely=0.33, often=0.66, always=1
- Each of these variables averaged at class/subject level represents the focus of our analysis

Some descriptive statistics

Table: Descriptive statistics; curriculum implementation strategies

	Reading		Mathematics	
	Mean	SD	Mean	SD
T1: Remain on the same topic until everyone understands	0.480	(0.104)	0.538	(0.094)
T2: Moving on to another topic even if someone did not understand	0.189	(0.093)	0.170	(0.091)
T3: Revising topics already studied in the previous year	0.572	(0.084)	0.569	(0.80)

More

Some descriptive statistics (cont.)

Table: Correlation matrix among curriculum implementation strategies

Teaching strategies	T1	T2	T3
T1	1.000		
T2	-0.236***	1.000	
T3	0.330***	-0.152***	1.000

Notes: The teaching strategies variables are a class average of students' perceptions excluding the student's *i* own observation. Pooled sample of subjects. Standard errors are clustered at class level. * significant at 10%; ** significant at 5%; *** significant at 1%.

▶ More

Some descriptive statistics (cont.)

Table: Correlation between curriculum implementation strategies and class characteristics

	T1: Remaining on the same topic until everyone understands	T2: Moving on to another topic even if someone did not understand	T3: Revising topic already studied in the previous yea
ESCS	-0.153***	-0.098***	-0.069***
(SD.) ESCS	0.007***	-0.016***	-0.069***
Class size	-0.029***	-0.016***	0.016***
Share of female students	-0.025***	-0.089***	-0.022***
Share of immigrants	-0.044***	0.115***	-0.044***
Share of retained students	0.033***	0.141***	-0.047***
Share of early entrance students	0.0280***	-0.052***	0.018***
Mid term school marks	-0.176***	-0.176***	-0.035**
(SD.) mid term school marks	0.148***	0.039***	-0.022***
(SK.) mid term school marks	0.063***	0.059***	0.002**

Empirical analysis

We estimate the following educational production function

$$y_{ijck} = \alpha_j + X'_{ick}\beta + T'_{ijck_{-i}}\delta + \varepsilon_{ijck}$$

y_{ijck}= test score of student i in subject $j \in [reading, math]$ in class/school ck (standardized: mean 0 and unitary Sd)

$T'_{ijck_{-i}}$= vector of the curriculum implementation strategies (i.e. T1, T2 and T3)

X'_{ick}= vector of students and class characteristics

Empirical analysis (cont.)

The effect of the teaching strategies could be confounded by correlated unobserved factors also related to students' performance

$$\varepsilon_{ijck} = \nu_i + \mu_c + \theta_k + \tau_{jck} + \epsilon_{ijck}$$

1. Parents may place their children into schools based on their ability and on teaching strategies endorsed by teachers
2. Students and teachers are not assigned randomly to classes (within schools)
3. Teachers could adapt their teaching technology to the level and to the distribution of the class ability
4. Teachers could sistematically sort into particular teaching strategies on the basis of their unobserved characteristics

Empirical analysis - solution

We use the fact that we have two observations for each student (reading, math) to take the first differences within each pupil

$$\Delta y_{ick} = \Delta T'_{ick\_i}\delta + \Delta\tau_{ck} + \Delta\epsilon_{ick}$$

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Remark: if $E(\Delta\tau_{ck}\Delta T'_{ick\_i}) \neq 0$ we cannot interpret the δs in a causal sense

Main results

Dependent variable:	(OLS)	(School FE)	(Student FE)	(Student FE)
6^{th} graders test score (standardized)				
T1	-0.5738***	-0.3184***	-0.1072***	-0.1054***
	(0.024)	(0.019)	(0.031)	(0.031)
T2	-0.5944***	-0.4286***	-0.1642***	-0.1622***
	(0.027)	(0.022)	(0.038)	(0.038)
T3	0.1150***	0.0566**	0.1694***	0.1687***
	(0.030)	(0.024)	(0.043)	(0.043)
Subject (reading)			0.1163***	0.1164***
			(0.005)	(0.005)
Subject × *gender*(*reading*, *male*)			-0.1635***	-0.1634***
			(0.004)	(0.004)
Subject × *imm.status*(*reading*, *imm.*)			-0.2490***	-0.2489***
			(0.008)	(0.008)
Mid term school marks (mean dev.)			0.1766***	0.1766***
			(0.003)	(0.003)
Sk. mid term school marks				-0.0074
				(0.007)
Observations	705,058	705,058	705,058	705,058

Breakdown by pupils' ability

- Do these strategies affect different students in the same way? (Winners and losers)
  - We split the sample according to the relative position of each student with respect to his or her classmates.
  - We use the mid term school marks averaged across subjects (taken in mean deviation from the class average) to stratify the sample in five non overlapping quintiles

Results by quintiles - within pupils estimates

	Within pupils estimates		
	T1	T2	T3
	(1)	(2)	(3)
a) Effects for	-0.0515	-0.1271**	0.2793***
percentiles below 20	(0.047)	(0.057)	(0.066)
b) Effects for	-0.0193	-0.1789***	0.1543**
percentiles 20-40	(0.049)	(0.060)	(0.067)
c) Effects for	-0.1222**	-0.1254**	0.1753***
percentiles 40-60	(0.050)	(0.067)	(0.069)
d) Effects for	-0.1439***	-0.1391**	0.0943
percentiles 60-80	(0.048)	(0.059)	(0.066)
e) Effects for	-0.1650***	-0.2076***	0.0748
percentiles above 80	(0.045)	(0.056)	(0.062)

Robustness checks

- Additional controls
- Alternative measures of the curriculum implementation strategies
- Relaxing $\delta_{read} = \delta_{math}$
- Quintile estimates on a restricted sample of homegenous pupils

Additional controls

	Within pupils estimates			
	(1)	(2)	(3)	(4)
T1	-0.1212***	-0.1214***	-0.1214***	-0.1200***
	(0.031)	(0.031)	(0.031)	(0.031)
T2	-0.1792***	-0.1793***	-0.1790***	-0.1777***
	(0.037)	(0.037)	(0.037)	(0.037)
T3	0.1371***	0.1373***	0.1376***	0.1348***
	(0.043)	(0.043)	(0.043)	(0.043)
ESCS*subject (reading)	0.0526***	0.0528***	0.0534***	0.0531***
	(0.007)	(0.007)	(0.007)	(0.007)
Sd.ESCS*subject (reading)		0.0048	0.0048	0.0040
		(0.015)	(0.015)	(0.015)
Class size*subject (reading)			-0.0005	-0.0004
			(0.001)	(0.001)
Share imm.*subject (reading)				0.0850**
				(0.036)
Observations	705,058	705,058	705,058	705,058

Alternative measures

	Within pupils estimates		
	Using only low achievers perceptions	Using only high achievers perceptions	mixed
	(1)	(2)	(3)
T1	-0.0427*	-0.0854***	-0.0532**
	(0.0249)	(0.0267)	(0.0255)
T2	-0.0619**	-0.1561***	-0.0682**
	(0.0279)	(0.0312)	(0.0277)
T3	0.1071***	0.0966***	0.1134***
	(0.0305)	(0.0331)	(0.0329)
Observations	705,058	705,058	705,058

Relaxing $\delta_{read} = \delta_{math}$

$$\Delta y_{ick} = y_{ick[read]} - y_{ick[math]} = T'_{ijck_{read-i}}\delta_{read} - T'_{ijck_{math-i}}\delta_{math} + \Delta\tau_{ck} + \Delta\epsilon_{ick}$$

$\hat{\delta}_{T1\,read}$	-0.0622**	-0.0671**	-0.0668**
	(0.026)	(0.026)	(0.026)
$\hat{\delta}_{T1\,math}$	0.1495***	0.1478***	0.1459***
	(0.023)	(0.023)	(0.023)
$\hat{\delta}_{T2\,read}$	-0.2039***	-0.2170***	-0.2162***
	(0.030)	(0.030)	(0.030)
$\hat{\delta}_{T2\,math}$	0.0930***	0.1072***	0.1055***
	(0.027)	(0.027)	(0.027)
$\hat{\delta}_{T3\,read}$	0.2026***	0.2009***	0.2009***
	(0.032)	(0.032)	(0.032)
$\hat{\delta}_{T3\,math}$	-0.0870***	-0.0817***	-0.0807***
	(0.026)	(0.026)	(0.026)

Quintiles estimates with homogenous individuals

	Within pupils estimates		
	T1	T2	T3
Effects for	-0.0602	-0.1392*	0.3330***
percentiles below 20	(0.070)	(0.084)	(0.098)
Effects for	-0.1149	-0.1770**	0.2612***
percentiles 20-40	(0.070)	(0.085)	(0.097)
Effects for	-0.0976	-0.1122	0.1193
percentiles 40-60	(0.074)	(0.089)	(0.103)
Effects for	-0.1737**	-0.0899	0.1347
percentiles 60-80	(0.068)	(0.084)	(0.095)
Effects for	-0.1677***	-0.2445***	0.0591
percentiles above 80	(0.065)	(0.080)	(0.089)

Conclusions

- Both T1 and T2 are not optimal strategies to endorse when some degree of heterogeneity within a class exists (negative results on average)
- T1 and T2 fail to be effective in improving learning of those students who intended to motivate (low achievers and high achievers)
  - T1 does not increase the performance of less able students while it reduces the learning of the more able ones
  - T2 reduces the performance at every point of the ability distribution
- T3 is an efficient way to deal with class heterogeneity
  - increases the performance of less able students without reducing the learning of the more able ones

Thank You

Unconditional distribution of teaching strategies

	T1	T2	T3
$T \in [0, 0.25]$	0.71	78.24	0.10
$T \in (0.25, 0.50]$	44.66	21.09	19.39
$T \in (0.50, 0.75]$	53.41	0.63	78.96
$T \in (0.75, 1]$	1.22	0.04	1.55

Notes: Unconditional distribution of curriculum implementation stategies. Share of teachers that adopt the strategy with a given intensity. Pooled sample of subjects. Observations at class level.

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Conditional distribution of teaching strategies

	$T2 \in [0, 0.25]$	$T2 \in (0.25, 0.50]$	$T2 \in (0.50, 0.75]$	$T2 \in (0.75, 1]$
$T1 \in [0, 0.25]$	39.22	48.28	12.07	0.43
$T1 \in (0.25, 0.50]$	74.32	25.02	0.66	0.00
$T1 \in (0.50, 0.75]$	85.21	14.57	0.21	0.01
$T1 \in (0.75, 1]$	88.62	10.84	0.00	0.54

Notes: Conditional distribution of strategies T1 and the T2, by intervals of intensity. Share of teachers that adopt the T2 practices with a given intensity on the total number of teachers adopting the T1 strategy for each interval of intensity. Pooled sample of subjects. Observations at class level.

Conditional distribution of teaching strategies

	T3 $\in [0, 0.25]$	T3 $\in (0.25, 0.50]$	T3 $\in (0.50, 0.75]$	T3 $\in (0.75, 1]$
T1 $\in [0, 0.25]$	1.72	56.47	41.81	0.00
T1 $\in (0.25, 0.50]$	0.06	26.05	73.42	0.47
T1 $\in (0.50, 0.75]$	0.01	12.67	85.50	1.82
T1 $\in (0.75, 1]$	0.04	18.98	79.61	1.37

Notes: Conditional distribution of strategies T1 and the T3, by intervals of intensity. Share of teachers that adopt the T3 practices with a given intensity on the total number of teachers adopting the T1 strategy for each interval of intensity. Pooled sample of subjects aggregated. Observations at class level.

Conditional distribution of teaching strategies

	$T3 \in [0, 0.25]$	$T3 \in (0.25, 0.50]$	$T3 \in (0.50, 0.75]$	$T3 \in (0.75, 1]$
$T2 \in [0, 0.25]$	0.04	16.92	81.62	1.43
$T2 \in (0.25, 0.50]$	0.03	26.50	72.38	1.10
$T2 \in (0.50, 0.75]$	1.14	55.68	42.05	1.14
$T2 \in (0.75, 1]$	0.00	25.00	25.00	50.00

Notes: Conditional distribution of strategies T2 and the T3, by intervals of intensity. Share of teachers that adopt the T3 practices with a given intensity on the total number of teachers adopting the T2 strategy for each interval of intensity. Pooled sample of subjects. Observation at class level.

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