Teaching Practices and Cognitive Skills

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Teaching Practices in American Schools

Long-standing debate among researchers, politicians, teachers, and parents: **Which teaching practices are best for student learning in schools?**

Teachers draw from two traditions of teaching:

1. **Teacher-centered "traditional teaching"**: teacher lectures, students memorize facts and formulas and solve drill worksheets.
2. **Student-centered "modern teaching"**: students work together in groups, explain the material to each other, and lead discussions.

Despite a century of reform efforts that tried to introduce modern teaching practices into schools, traditional teaching practices still dominated in American classrooms by the year 1990 (Cuban 1993).

Since then, however, modern teaching practices have gained considerable support with the adoption of **National Teaching Standards (NTS)**.

National Teaching Standards (NTS)

NTS refers to a series of documents released in the 1990s and 2000s that call for a reform of teaching in schools in the United States.

- Authored by national teacher organizations and other professional education bodies and endorsed by the Department of Education.
- **Common recommendation: place more emphasis on modern teaching practices relative to traditional ones.**
- Rationale: **modern teaching promotes logical reasoning skills,** which are increasingly important in the labor market.

NTS had a large influence on teacher training and education programs. Empirical evidence suggests that there has indeed been a (slow) shift from traditional towards modern teaching practices over the past 20 years.

The Impact of Teaching Practices: Empirical Evidence

Small literature on the effects of teaching practices on test scores.

Empirical evidence lends little support to NTS recommendations.

- Murnane and Phillips (1981) and Goldhaber and Brewer (1997): teachers who emphasize modern teaching practices (such as working in small groups) are associated with lower student test scores.
- Schwerdt and Wuppermann (2011): teachers who spend more time lecturing are associated with higher test scores in the United States.
- Lavy (2011): traditional teaching practices have a considerably larger positive effect than modern teaching practices on test scores in Israel.

Do we have to conclude that NTS are wrong in calling for a shift from traditional towards modern teaching practices in schools?

This Paper

Alternative hypothesis explored in this paper:

- Traditional and modern teaching practices promote different cognitive skills in students, and in particular,
- modern teaching practices do promote reasoning skills as assumed by NTS, but these skills are not measured well in standardized tests.

In order to test this hypothesis, I

- use data from the Trends in International Mathematics and Science Study (TIMSS) for United States 8th-grade students,
- measure teaching practices using information on classroom activities from a student questionnaire, and I
- exploit the within-student between-subject variation in teaching practices in the data to control for the most obvious confounders.

Data: TIMSS 2007

TIMSS is an international assessment of the math and science knowledge of 4th- and 8th-grade students.

- Repeated cross section; conducted every four years since 1995.
- In this paper, focus on the nationally representative sample of United States 8th-grade students tested in 2007.

Key design features:

- Students take standardized tests in math and science (=> each student is observed twice) and answer a student questionnaire.
- Rich information on teacher traits from a teacher questionnaire.

Initial sample of 7,377 students is reduced to 6,057 students after dropping outliers and observations with missing information on essential variables.

Measuring Teaching Practices

The **student questionnaire** asked students to rate on a four-point scale how often they engaged in a range of different activities in class.

- Students responded separately for math and for science.
- Code the answers as follows: 0 = "never", 0.25 = "some lessons", 0.5 = "about half the lessons", 1 = "every or almost every lesson".

Categorize activities as reflecting either a traditional or a modern teaching practice by referring to NTS.

- **Traditional:** (1) listening to the teacher lecture, (2) memorizing facts, formulas and procedures, and (3) working routine problems.
- **Modern:** (1) working in small groups, (2) giving explanations, and (3) relating what is learned in class to students' daily lives.

Measuring Teaching Practices (continued)

Construct two teaching practice indices at the class level.

1. For each student, compute the mean of her answers across all traditional (all modern) teaching practices.
2. Compute the average of the resulting composite measures across all students in a class while excluding each student's own answer.

Interpretation of the indices: how frequently does a teacher use traditional (modern) teaching practices with a particular class?

Note: no mechanical trade-off between the indices ($\rho = 0.22$).

- Headline specification: both indices as multiple treatments.
- Alternative specification: difference between indices as treatment.

Measuring Cognitive Skills

The standardized tests in TIMSS measured students' knowledge of the 8th-grade math and science curriculum (similar to NAEP).

Tests were organized along **three cognitive domains:**

1. **Knowing:** measures students' ability to recall definitions and facts and to recognize known characteristics (shapes of objects...).
2. **Applying:** measures students' competency in solving routine problems which typically have been practiced in classroom exercises.
3. **Reasoning:** measures students' capacity for logical, systematic thinking by confronting them with more complex problems.

Measuring Cognitive Skills (continued)

Each question on the tests belongs to one of these domains.

Distribution of questions over cognitive domains is uneven:
36% knowing, 41% applying, and 23% reasoning.

- Questions measuring reasoning skills - the ones emphasized by NTS - only account for a relatively small part of the assessment.
- This is **not an idiosyncratic feature of the TIMSS tests**, but a well-known feature (or deficiency) of standardized tests more generally.

The empirical analysis exploits the fact that the data contains both test scores for overall achievement and for achievement in each of the three cognitive domains separately for each subject.

Identification: Within-Student Between-Subject Variation

Two main concerns regarding identification:

1. Students sort into schools and to teachers within schools based on (unobserved) preferences for particular teaching practices.
2. Teachers adjust their teaching practices to their students.

Address these issues by estimating a **student fixed-effects model** which exploits the fact that each student is observed in two different subjects:

$$A_{ijs} = \alpha + \beta_1 TradTI_{ijs} + \beta_2 ModnTI_{ijs} + \mathbf{X}_{js}\gamma + \lambda_i + \varepsilon_{ijs}$$

where i indexes students, j indexes teachers, and s indexes subjects.

Identifying assumption: ε_{ijs} is uncorrelated with $TradTI_{ijs}$ and $ModnTI_{ijs}$ conditional on the other variables.

Threats to Identification

Threat 1: student sorting based on subject-specific academic ability.

- Math and science arguably require very similar skills.
- Clotfelter, Ladd, and Vigdor (2010) provide evidence based on tracking patterns that academic ability is highly correlated across subjects.

Threat 2: unobserved teacher traits are correlated with the treatments.

- Regressions include a rich set of teacher controls.
- Cannot completely exclude the possibility that coefficient estimates actually pick up the effect of some other unobserved teacher trait.

Threat 3: Teachers adapt their teaching practices to the students.

- OK if practices are a function of subject-invariant student ability.

Results: Teaching Practices and Overall Test Scores

	Overall Test Score				
	(1)	(2)	(3)	(4)	(5)
Traditional teaching index	0.328**		0.317**	0.307**	0.317**
[mean: 0.63; sd: 0.10]	(0.105)		(0.108)	(0.106)	(0.107)
Modern teaching index		0.105	0.065	0.064	0.058
[mean: 0.53; sd: 0.11]		(0.114)	(0.116)	(0.117)	(0.118)
Teacher controls				Y	Y
Class controls					Y
Number of students	6,057	6,057	6,057	6,057	6,057
Average *R*-squared	0.924	0.923	0.924	0.924	0.924
H_0: TradTI = ModnTI (*p* value)			0.149	0.158	0.136

Results: Teaching Practices and Cognitive Skills

	Overall	Knowing	Applying	Reasoning
	(1)	(2)	(3)	(4)
Traditional teaching index	0.317**	0.418**	0.359**	0.036
	(0.107)	(0.134)	(0.123)	(0.136)
Modern teaching index	0.058	0.007	-0.014	0.221*
	(0.118)	(0.105)	(0.119)	(0.110)
Teacher controls	Y	Y	Y	Y
Class controls	Y	Y	Y	Y
Number of students	6,057	6,057	6,057	6,057
Average *R*-squared	0.924	0.857	0.853	0.824
H_0: TradTI = ModnTI (*p* value)	0.136	0.019	0.040	0.337

Discussion of Results

In line with the previous literature, find that **traditional but not modern teaching has a sizable positive effect on overall test scores.**

Heterogeneous effects across cognitive skills:

- Sizable effect of traditional teaching on factual knowledge and on routine problem solving skills but not on reasoning skills.
- Zero effect of modern teaching index on factual knowledge and on routine problem solving skills but sizable effect on reasoning skills.

Effect of modern teaching on reasoning is masked in the overall test score regression because questions measuring reasoning skills accounted for only a small part of the assessment.

- Again: this is not an idiosyncratic feature of the TIMSS tests!

Discussion of Results (continued)

Implications for National Teaching Standards: a higher emphasis on modern teaching practices is not associated with higher test scores, but does indeed raise students' reasoning skills. A lower emphasis on traditional teaching practices is associated with lower test scores.

Robustness to using alternative measurements of teaching practices

- Assigning different numerical values to the answer categories.
- Excluding individual teaching practices from the indices one at a time.
- Using *TradTI - ModnTI* as a treatment (a measurement of the *relative* frequency of use of traditional vs modern teaching practices).

Extension: estimates for 9 other advanced economies for which comparable data is available are quantitatively and qualitatively similar.

Conclusion

Previous empirical evidence: teachers emphasizing traditional rather than modern teaching practices are associated with higher test scores.

This seems to be at odds with the suggestion by NTS to increase the use of modern teaching at the cost of traditional teaching.

I show that traditional and modern teaching practices promote different cognitive skills in students.

- The small impact of modern teaching on test scores found in the previous literature is not due to general ineffectiveness.
- Rather, the reasoning skills that modern teaching practices promote are not measured well in standardized tests.

If teachers' goal is to promote test scores, need to adjust standardized tests in order to foster reasoning skills.

Appendix: Robustness to Alternative Measurements of TP

	Overall	Knowing	Applying	Reasoning
	(1)	(2)	(3)	(4)
	(A) Share of answers ≥ "about half the lessons"			
Traditional teaching index	0.270**	0.315**	0.283**	0.087
	(0.100)	(0.112)	(0.103)	(0.108)
Modern teaching index	0.044	0.024	-0.020	0.228*
	(0.087)	(0.086)	(0.092)	(0.089)
Average *R*-squared	0.924	0.857	0.853	0.824
H_0: TradTI = ModnTI (*p* value)	0.111	0.047	0.037	0.349
	(B) Gap between traditional and modern teaching			
TradTI – ModnTI	0.103	0.176*	0.162~	-0.110
	(0.089)	(0.086)	(0.091)	(0.095)
Average *R*-squared	0.924	0.856	0.853	0.824

Appendix: International Evidence

	Overall	Knowing	Applying	Reasoning
	(1)	(2)	(3)	(4)
	(A) Other Anglo-Saxon countries + Israel			
Traditional teaching index	0.392**	0.651**	0.411**	-0.105
	(0.085)	(0.139)	(0.125)	(0.136)
Modern teaching index	-0.019	-0.130	-0.122	0.324**
	(0.077)	(0.094)	(0.107)	(0.110)
Average *R*-squared	0.925	0.850	0.852	0.822
H_0: TradTI = ModnTI (*p* value)	0.001	0.000	0.003	0.030
	(B) East and Southeast Asian countries			
Traditional teaching index	0.340**	0.437**	0.372**	0.103
	(0.087)	(0.126)	(0.133)	(0.166)
Modern teaching index	0.144	0.025	0.137	0.367**
	(0.091)	(0.122)	(0.107)	(0.114)
Average *R*-squared	0.923	0.849	0.861	0.829
H_0: TradTI = ModnTI (*p* value)	0.198	0.048	0.273	0.252