

# Instruction Time and Student Achievement: The Moderating Role of Teacher Qualifications

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# Motivation

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- **Quantity and quality** of instruction important for student achievement → trade-off:
  - Effect of instruction time might depend on instructional and teacher quality
- **Instruction time** as an input to education production function and interact it with **teacher qualifications** as a measure for teacher quality
- Recent studies find a **positive impact** of instruction time on student achievement (Lavy (EJ, 2015), Rivkin & Schiman (EJ, 2015))
  - Effect of instruction time is smaller in developing countries than developed countries
  - Effect of instruction time is larger in classrooms with better environments in terms of student behavior

## Research Question

To what extent is the effect of instruction time on student achievement moderated by better qualified teachers?

## Data & Method

- Data: Trends in International Mathematics and Science Study
- Method: Student fixed effects model

## Main Findings

- One hour more instruction time increases student test scores by 0.03 standard deviations
  - No effect in developing countries
- Teacher qualifications moderate the effect of instruction time
  - Especially in developing countries: instruction time by a high-qualified teacher increases test scores by 0.02 standard deviations

## Trends in International Mathematics and Science Study (TIMSS)

- Cross-sectional data, wave 2015, 4<sup>th</sup> grade
- Final sample: **115,071 students** in 42 countries ▶ Participating Countries
  - 2 observations per student (math/science)
- Variables
  - Dependent variable: standardized **test score** in math/science
  - Alternative: student's **motivation/attitude** towards math/science
  - Main independent variable: **instruction time** (hours per week) in math/science (aggregated on school by subject level), reported by teachers
  - Further variables: student, teacher, school and country characteristics

▶ Descriptive Statistics

## Teacher Qualifications

- **Professional development** during the last 2 years (yes/no)
- **Teacher training with specialization** in the relevant subject (yes/no)
- Completed the relevant subject as a **main subject with a Bachelor's degree** (or higher) (yes/no)
- **Experience** (in years)

▶ Questions

▶ Teacher Descriptives

## Student Fixed Effects Model

- Uses **within-student between-subject** variation
- Accounts for individual-specific factors (constant within individuals)
- Controls for unobservable student characteristics (e.g. unobserved ability) → no heterogeneity in ability, habits or school quality

## Limitations

- Effect of instruction time assumed to be the same for both subjects
- Impact of instruction time is net of spillovers from other subjects

$$\text{test score}_{ijk} = \beta_1 H_{kj} + \beta_2 X_{ij} + \beta_3 Q_{lj} + \mu_i + \epsilon_j + \eta_k + u_{ijk} \quad (1)$$

- test score<sub>ijk</sub>: test score of student  $i$  in school  $j$  in subject  $k$  ( $k \in$  math, science)
- $H_{kj}$ : instruction time (in hours) in school  $j$  in subject  $k$
- $X_{ij}$ : student characteristics of student  $i$  in school  $j$  and teacher characteristics
- $Q_{lj}$ : teacher characteristics of teacher  $l$  in school  $j$
- $\mu_i$ : student fixed effects
- $\epsilon_j$ : unobserved school characteristics
- $\eta_k$ : unobserved subject-specific characteristics
- $u_{ijk}$ : error term

$$\text{test score}_{ijk} = \beta_1 H_{kj} + \beta_2 X_{ij} + \beta_3 Q_{lj} + \beta_4 H_{kj} Q_{lj} + \mu_i + \epsilon_j + \eta_k + u_{ijk} \quad (2)$$

- $Q_{lj}$ : teacher qualifications of teacher  $l$  in school  $j$ 
  - Professional development
  - Teacher education with specialization
  - Major in the relevant subject and Bachelor (or higher) degree
  - Experience



Table 1: Baseline Results

VARIABLES	(1) test score	(2) test score	(3) test score
Instruction time	0.032*** (0.003)	0.032*** (0.003)	0.038*** (0.003)
female x instruction time			-0.013*** (0.002)
Observations	230,142	230,142	230,142
R-squared	0.923	0.923	0.923
Student FE	Yes	Yes	Yes
Subject FE	Yes	Yes	Yes
Teacher Controls	No	Yes	Yes

Clustered standard errors at school level in parentheses  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Notes: The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level. Regressions run as in equation 1.

Table 1: Baseline Results

VARIABLES	(1) test score	(2) test score	(3) test score	(4) like subject	(5) like subject
Instruction time	0.032*** (0.003)	0.032*** (0.003)	0.038*** (0.003)	0.051*** (0.006)	0.064*** (0.006)
female x instruction time			-0.013*** (0.002)		-0.026*** (0.004)
Observations	230,142	230,142	230,142	214,102	214,102
R-squared	0.923	0.923	0.923	0.608	0.608
Student FE	Yes	Yes	Yes	Yes	Yes
Subject FE	Yes	Yes	Yes	Yes	Yes
Teacher Controls	No	Yes	Yes	Yes	Yes

Clustered standard errors at school level in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Notes: The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level. Regressions run as in equation 1.

# Results - Instruction Time & Teacher Qualifications

Table 2: Results for teachers' formal qualification

VARIABLES	(1) test score	(2) test score	(3) test score	(4) test score
Instruction time	0.017*** (0.004)	0.027*** (0.003)	0.027*** (0.003)	0.036*** (0.003)
PD x instruction time	0.025*** (0.004)			
education specialization x instruction time		0.022*** (0.005)		
major degree x instruction time			0.027*** (0.005)	
experience x instruction time				-0.012*** (0.004)
Observations	230,142	230,142	230,142	230,142
R-squared	0.923	0.923	0.923	0.923
Student FE	Yes	Yes	Yes	Yes
Subject FE	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes
effect for high qualification	0.042*** (0.00351)	0.050*** (0.00501)	0.054*** (0.00475)	0.024*** (0.00397)

Clustered standard errors at school level in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Notes: The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level. Regressions run as in equation 2. PD stands for professional development. Effect for high qualification shows the coefficient on instruction time when the respective teacher qualification (PD, education specialization, major degree, experience) equals 1.

# Results - Instruction Time & Teacher Qualifications

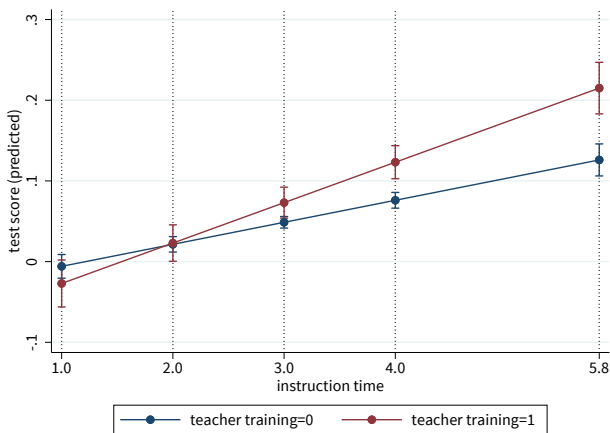


Figure 1: Teacher training with specialization

Table 3: Results by **country group** by gender

VARIABLES	(1)	(2)	(3)	(4)
	developed countries test score	test score	developing countries test score	test score
Instruction time	0.062*** (0.003)	0.068*** (0.004)	0.001 (0.006)	0.008 (0.006)
female x instruction time		-0.013*** (0.002)		-0.013*** (0.004)
Observations	143,240	143,240	86,902	86,902
R-squared	0.907	0.907	0.940	0.940
Student FE	Yes	Yes	Yes	Yes
Subject FE	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes

Clustered standard errors at school level in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Notes: The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level. Regressions run as in equation 1. Countries are grouped into developed and developing countries according to the WESP classification.

# Results - Country Analysis

Table 4: Results for **developing** countries

VARIABLES	(1) test score	(2) test score	(3) test score	(4) test score
Instruction time	-0.028*** (0.009)	-0.004 (0.008)	-0.014** (0.007)	0.008 (0.007)
PD x instruction time	0.043*** (0.008)			
education specialization x instruction time		0.010 (0.008)		
majordegree x instruction time			0.038*** (0.008)	
experience x instruction time				-0.018** (0.008)
Observations	86,902	86,902	86,902	86,902
R-squared	0.940	0.940	0.940	0.940
Student FE	Yes	Yes	Yes	Yes
Subject FE	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes
effect for high qualification	0.016** (0.00632)	0.007 (0.00691)	0.024*** (0.00711)	-0.010 (0.00776)

Clustered standard errors at school level in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Notes: Sample restricted to developing countries. The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level. Regressions run as in equation 2. PD stands for professional development. Effect for high qualification shows the coefficient on instruction time when the respective teacher qualification (PD, education specialization, major degree, experience) equals 1.

# Robustness Checks

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- Within-teacher specification (same teacher in both subjects) [▶ Results](#)
- Country outlier (including interaction with teacher qualifications)
- Non-linear effect? (including squared instruction time)
- Tracking?
  - Question: "As a general school policy, is student achievement used to assign fourth grade students to classes?"
- Instruction time as reported by teachers (not aggregated on school-by-subject level)
- Schools in remote areas
  - Students cannot choose between different schools

[▶ Robustness Checks](#)

# Conclusion

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- Positive effect of instruction time on test scores
  - One hour more instruction time increases test scores by 0.03 standard deviations
  - Similar in magnitude to previous literature
- Teacher qualifications moderate effect of instruction time on test scores
  - Especially in developing countries, teacher qualifications are important: instruction time by a high-qualified teacher increases test scores by 0.02 standard deviations

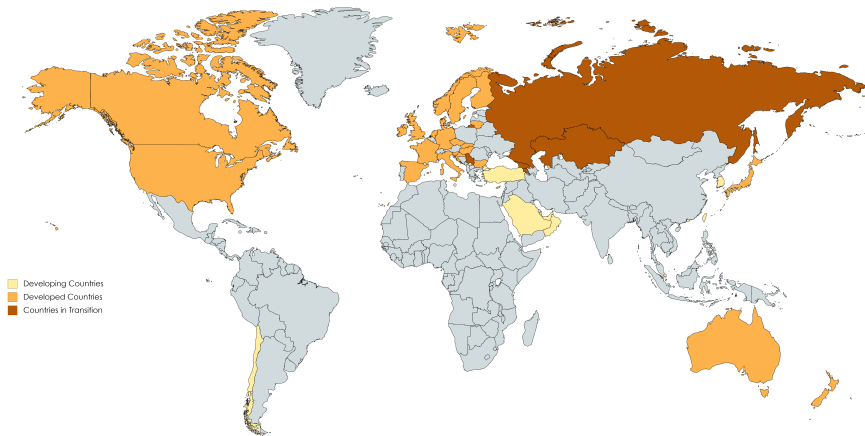


Thank you for your attention!  
Comments and questions are welcome.

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# APPENDIX

# Participating Countries



Credited with mapchart.net

- **Developing Countries:** Chile - Chinese Taipei - Hong Kong - Korea (Republic) - Oman - Qatar - Saudi Arabia - Singapore - United Arab Emirates - Turkey
- **Developed Countries:** Australia - Bulgaria - Canada - Croatia - Cyprus - Czech Republic - Denmark - England - Finland - France - Germany - Hungary - Ireland - Italy - Japan - Lithuania - Netherlands - New Zealand - Northern Ireland - Norway - Poland - Slovak Republic - Slovenia - Spain - Sweden - United States
- **Countries in Transition:** Armenia - Georgia - Kazakhstan - Russian Federation - Serbia

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Table 5: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
instruction time	2.955	1.513	0.017	10	230,142
female	0.489	0.5	0	1	230,142
teacherfemale	0.832	0.374	0	1	230,142
teacheraage	42.502	9.67	25	60	230,142
PD	0.493	0.5	0	1	230,142
education specialization	0.273	0.446	0	1	230,142
major degree	0.236	0.425	0	1	230,142
experience	0.519	0.5	0	1	230,142
tracking	0.141	0.348	0	1	219,271
remote	0.328	0.47	0	1	223,282
developed	0.635	0.481	0	1	230,142
developing	0.365	0.481	0	1	230,142

*test scores and like subject are standardized (mean 0, std. dev. 1)*

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Table 6: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
instruction time	2.955	1.513	0.017	10	230,142
female	0.489	0.5	0	1	230,142
teacherfemale	0.832	0.374	0	1	230,142
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PD	0.493	0.5	0	1	230,142
education specialization	0.273	0.446	0	1	230,142
major degree	0.236	0.425	0	1	230,142
experience	0.519	0.5	0	1	230,142
tracking	0.141	0.348	0	1	219,271
remote	0.328	0.47	0	1	223,282
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test scores are standardized (mean 0, std. dev. 1)

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# Results - Instruction Time & Teacher Qualifications

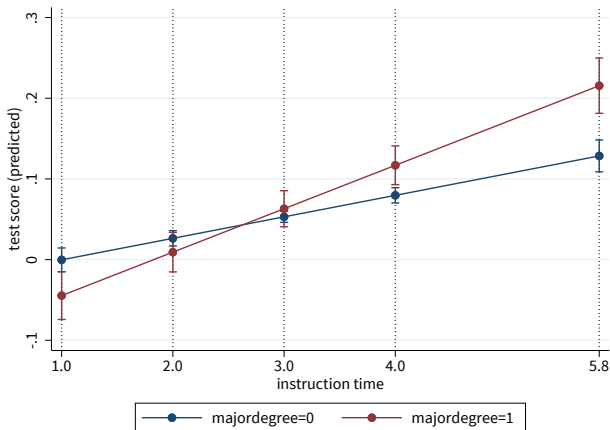


Figure 2: Major degree

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# Results - Developing Countries

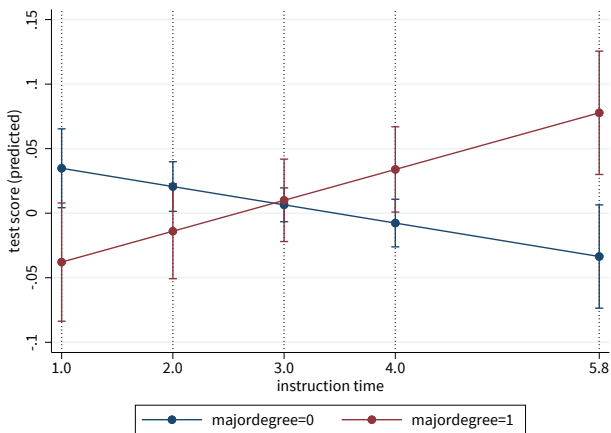


Figure 3: Major degree

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# Results - Developing Countries

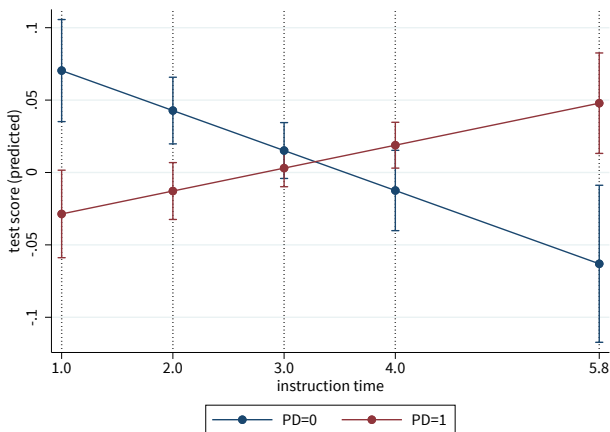


Figure 4: Professional Development

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# Results - Country Analysis (developed countries)

Table 7: Results for **developed** countries

VARIABLES	(1) test score	(2) test score	(3) test score	(4) test score
Instruction time	0.059*** (0.004)	0.060*** (0.003)	0.060*** (0.004)	0.063*** (0.004)
PD x instruction time	0.003 (0.005)			
education specialization x instruction time		0.017*** (0.006)		
major degree x instruction time			0.017*** (0.006)	
experience x instruction time				-0.005 (0.004)
Observations	143,240	143,240	143,240	143,240
R-squared	0.907	0.907	0.907	0.907
Student FE	Yes	Yes	Yes	Yes
Subject FE	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes
effect for high qualification	0.063*** (0.00410)	0.077*** (0.00692)	0.077*** (0.00606)	0.059*** (0.00430)

Clustered standard errors at school level in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Notes: Sample restricted to developed countries. The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level. Regressions run as in equation 2. PD stands for professional development. Effect for high qualification shows the coefficient on instruction time when the respective teacher qualification (PD, education specialization, major degree, experience) equals 1.

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Table 8: **Within-teacher specification**

VARIABLES	(1) test score	(2) test score	(3) test score	(4) test score	(5) test score
Instruction time	0.035*** (0.003)	0.030*** (0.004)	0.033*** (0.003)	0.031*** (0.003)	0.039*** (0.004)
PD x instruction time		0.010** (0.004)			
education specialization x instruction time			0.016*** (0.005)		
major degree x instruction time				0.028*** (0.005)	
experience x instruction time					-0.010*** (0.004)
Observations	163,994	163,994	163,994	163,994	163,994
R-squared	0.922	0.922	0.922	0.922	0.922
Student FE	Yes	Yes	Yes	Yes	Yes
Subject FE	Yes	Yes	Yes	Yes	Yes
Teacher Controls	No	No	No	No	No

Clustered standard errors at school level in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Notes: Sample restricted to students with only one teacher in both subjects. The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level. Regressions run as in equation 2. PD stands for professional development. Effect for high qualification shows the coefficient on instruction time when the respective teacher qualification (PD, education specialization, major degree, experience) equals 1.

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Table 9: Robustness Checks

VARIABLES	(1) test score	(2) tracking: yes test score	(3) tracking: no test score	(4) remote: yes test score	(5) remote: no test score	(6) test score	(7)
Instruction time	0.019** (0.008)	0.040*** (0.008)	0.029*** (0.004)	0.038*** (0.006)	0.027*** (0.004)	0.032*** (0.003)	0.032***
squared	0.002 (0.001)						
Observations	230,142	24,374	173,202	58,448	164,834	230,142	
R-squared	0.923	0.944	0.918	0.915	0.925	0.923	
Student FE	Yes	Yes	Yes	Yes	Yes	Yes	
Subject FE	Yes	Yes	Yes	Yes	Yes	Yes	
Teacher Controls	Yes	Yes	Yes	Yes	Yes	No	

Clustered standard errors at school level in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Notes: The dependent variable is a student's test score in math/science. Instruction time is aggregated on school-by-subject level in column 1 to 5, not in column 6. Regressions run as in equation 1. *Tracking:yes* indicates that only the sub-sample of observations where tracking is used as school policy is used. *remote: yes* indicates that only the sub-sample of observations in remote areas is used.

# Questionnaire - Having a degree & Specialization

ATBG04	What is the highest level of formal education you have completed?
ATBG05AA	During your <post-secondary> education, what was your major or main area(s) of study? Education—Primary/Elementary
ATBG05AB	During your <post-secondary> education, what was your major or main area(s) of study? Education—Secondary
ATBG05AC	During your <post-secondary> education, what was your major or main area(s) of study? Mathematics
ATBG05AD	During your <post-secondary> education, what was your major or main area(s) of study? Science
ATBG05AE	During your <post-secondary> education, what was your major or main area(s) of study? <language of test>
ATBG05AF	During your <post-secondary> education, what was your major or main area(s) of study? Other
ATBG05BA	If your major or main area of study was education, did you have a <specialization> in any of the following? Mathematics
ATBG05BB	If your major or main area of study was education, did you have a <specialization> in any of the following? Science
ATBG05BC	If your major or main area of study was education, did you have a <specialization> in any of the following? Language/reading
ATBG05BD	If your major or main area of study was education, did you have a <specialization> in any of the following? Other subject

Figure 5: Questions - Having a degree & Specialization

# Questionnaire - Professional Development

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ATBM09A	In the past two years, have you participated in professional development in any of the following? Mathematics content
ATBM09B	In the past two years, have you participated in professional development in any of the following? Mathematics pedagogy/instruction
ATBM09C	In the past two years, have you participated in professional development in any of the following? Mathematics curriculum
ATBS08A	In the past two years, have you participated in professional development in any of the following? Science content
ATBS08B	In the past two years, have you participated in professional development in any of the following? Science pedagogy/instruction
ATBS08C	In the past two years, have you participated in professional development in any of the following? Science curriculum

Figure 6: Questions - Professional Development

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