# The effect of classroom rank on learning throughout elementary school: experimental evidence from Ecuador

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# Introduction

- Rank might play a role for educational outcomes: big fish-little pond (Marsh 1987)
- Growing literature quantifying importance of rank in education, looking at short- and long-run outcomes
  - Academic achievement: Elsner and Isphording, 2017; Murphy and Weinhardt, 2021; Elsner, Isphording and Zölitz, 2021
  - Earnings: Denning, Murphy and Weinhardt, 2021
  - Risky behaviors: Elsner and Isphording, 2018

# This paper

- Estimate impact of classroom rank on learning and other outcomes throughout elementary school
- Unique experiment in elementary school in Ecuador: at the start of every grade from KG, cohort of students randomly assigned across classrooms within schools
- Random assignment: two students with the same ability, in same school and grade have different classroom ranks
- Longitudinal setting: study differences in effects of rank on achievement by grade, and how they evolve over time
- Rich data on executive function, non-cognitive outcomes and teacher perceptions allows to investigate potential mechanisms

# Preview of results

- Increasing child's classroom rank in math at the start of given grade (keeping ability constant) raises end-of-grade achievement
- Effect is largest in early grades ($1^{st}$ and $2^{nd}$) and increases substantially over time
- Potential mechanism: classroom rank positively affects an unobserved skill that fosters learning
- We find positive effects of classroom rank on executive function, happiness and teachers' perceptions of student ability

# Setting

- Experiment in Ecuador involving 202 schools over school years 2012-2018
- Cohort randomly assigned to KG classrooms within schools in 2012, reassigned to 1st grade classrooms in 2013, to 2nd grade classrooms in 2014, etc. until 6th grade in 2018
- Random assignment ensures we deal with concerns about purposeful matching of students with teachers/peers that arise in non-experimental settings

Random assignment Variation in classroom rank

# Data

- Math and language achievement between KG and $6^{th}$ grade
- Executive function up to $4^{th}$ grade
- Yearly teachers' assessments: top/bottom 5 students in terms of learning achievement
- Data on students' happiness ($1^{st}$ grade), depression, self-esteem, growth mindset, grit ($6^{th}$ grade)

Summary stats

# Measuring classroom rank

- In each school, children are randomly assigned to classrooms at the start of every grade
- Random set of peers in each grade means students with same underlying ability can have different classroom ranks
- Exploit this variation by estimating impact of rank at the *beginning of* grade $t$ on learning at the end of grade $t$, and learning in later grades
- Classroom rank in $t$ is based on student (and her randomly-assigned classmates') achievement at the end of $t-1$

Variation in classroom rank

# Main model

## Contemporaneous effect of classroom rank

- Let $Y_{i,s,c,t}$ be student $i$'s math performance at the end of grade $t$, in school $s$, in classroom $c$
- $Y_{i,s,c,t}$ defined in terms of percentiles of national rank
- $CR_{i,s,c,t}$ is student $i$'s classroom rank in math at the beginning of grade $t$, when she is randomly assigned to classroom $c$
- We estimate

$$Y_{i,s,c,t} = \beta_t CR_{i,s,c,t} + g_t(Y_{i,s,c,t-1}) + \delta_{s,t} + \epsilon_{i,s,c,t} \quad (1)$$

- Where $t$ is early ($1^{st}$ & $2^{nd}$), middle ($3^{rd}$ & $4^{th}$) and late ($5^{th}$ & $6^{th}$) grades

# Dynamics

## Medium-term effect of classroom rank

- Estimate medium-term effects of classroom rank in early ($1^{st}$ & $2^{nd}$), middle ($3^{rd}$ & $4^{th}$) grades on *future* achievement

$$Y_{i,s,c,t+l} = \beta_{t,l} CR_{i,s,c,t} + g_{t+l}(Y_{i,s,c,t-1}) + \delta_{s,t+l} + \epsilon_{i,s,c,t+l} \quad (2)$$

- When $l > 0$, (2) estimates medium-term effect of classroom rank at various lags

# Dynamics

Medium-term impact $\beta_{t,l}$ and contemporaneous impact $\beta_{t,0}$ of classroom rank are related through 2 potential mechanisms

1. virtuous cycle: high rank in $t$ leads to higher learning at end of $t$ + higher rank in $t+1$ and higher learning in $t+1 \rightarrow$ dynamic interplay between rank/learning

# Dynamics

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1. virtuous cycle: high rank in $t$ leads to higher learning at end of $t$ + higher rank in $t+1$ and higher learning in $t+1 \rightarrow$ dynamic interplay between rank/learning
2. unobservables: effect of rank on unobserved skills at the end of $t$ that can affect future learning

# Dynamics

We quantify importance of these channels by comparing estimates of

1. simple dynamic "structural" model linking classroom rank in $t$ with learning at the end of $t$, and future learning and ranks

2. reduced form estimates of classroom rank in $t$ on future learning

$\Rightarrow$ Observed differences between estimates of 1. and 2. tell us about importance of unobserved skills

# Executive function and teacher perceptions

Replace achievement with the relevant outcome:

- Executive function between end of $1^{st}$ and $4^{th}$ grade
- Indicators for being in the top/bottom 5 achieving students in the classroom according to teacher between end of $1^{st}$ and $6^{th}$ grade (conditional on achievement)

# Contemporaneous and medium-term effects of classroom rank on learning

Table: Effects of math classroom rank on math achievement, by grade and lag

| | Lags | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| Rank, early (1st & 2nd grades) | 0.042*** | 0.052*** | 0.057*** | 0.072*** | 0.077*** |
| | (0.014) | (0.016) | (0.017) | (0.018) | (0.018) |
| Rank, middle (3rd & 4th grades) | 0.040*** | 0.032** | 0.028* | | |
| | (0.012) | (0.014) | (0.015) | | |
| Rank, late (5th & 6th grades) | -0.005 | | | | |
| | (0.010) | | | | |

Notes: The table reports estimates from regressions of national rank in math on classroom math rank for different lags of classroom rank, separately for children in the early (1st and 2nd), middle (3rd and 4th), and late grades (5th and 6th) grades. All regressions are limited to schools in which there are at least two classes. All regressions include a third order polynomial in lagged national rank in math and school-by-grade fixed effects. Standard errors are clustered at the student level. N varies by period and lag, from 21,012 for regressions of the effect of early rank on achievement after 4 lags, to 30,940 for regressions of the effect of late rank on achievement with no lags. *Significant at 10%, **significant at 5%, ***significant at 1%.

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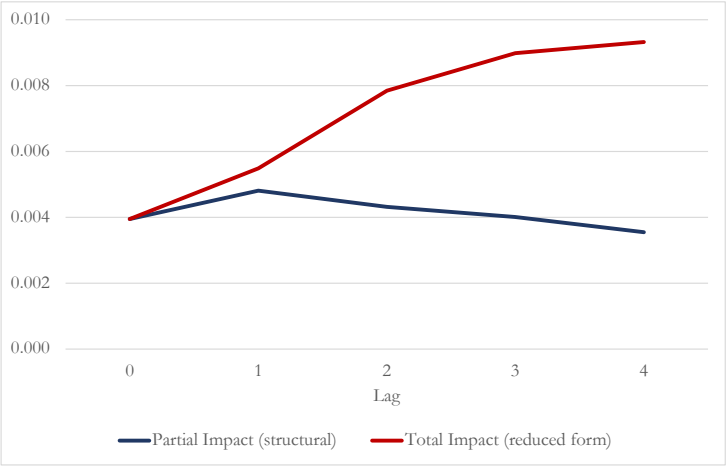
# Dynamics

- Effects of early classroom rank on learning increase substantially and significantly over time
- Can we account for this increase using estimates of the "virtuous cycle" model, i.e rank operates primarily through short-term gains in learning + the resulting improvement in subsequent rank?
- Our estimates suggest that early classroom rank affects future learning through other channels, such as through unobservable skills

# Change in learning in $t + l$ in response to a change in early classroom rank ($t = 0$): "structural" vs. reduced-form




Notes: The figure plots the implied change in learning in grades $t + l$, in response to an exogenous change in early classroom rank by 10 points, under two scenarios: (1) using the reduced form estimates of early classroom rank on learning in later grades; and (2) using estimates of the "virtuous cycle" model, then simulating the response to a particular change in early rank. For the purpose of illustration, we normalize estimate of $\beta_{0,t}$ to be the same

# Executive function

Table: Effects of math classroom rank on executive function

| | Lags | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Rank, early (1st & 2nd grades) | 0.071 | 0.202*** | 0.021 |
| | (0.061) | (0.064) | (0.067) |
| Rank, middle (3rd & 4th grades) | 0.038 | | |
| | (0.061) | | |

Notes: The table reports estimates from regressions of executive function, in SDs, on classroom achievement rank in math, for different lags of classroom rank, separately for children in the early (1st and 2nd) and middle (3rd and 4th) grades. All regressions include third order polynomials in lagged national rank in math, a third-order polynomial in lagged executive function, and school-by-grade fixed effects. All regressions are limited to schools in which there are at least two classrooms per grade. We cannot assess the impact of classroom rank past 4th grade, as we did not apply executive function tests after that grade. *Significant at 10%, **significant at 5%, ***significant at 1%.

# Teacher perceptions

Table: Effects of math classroom rank on teacher perceptions: top 5 student

| | Lags | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Rank, early (1st & 2nd grades) | 0.071*** | 0.077*** | 0.048** | 0.032 |
| | (0.024) | (0.023) | (0.024) | (0.023) |
| Rank, middle (3rd & 4th grades) | 0.051** | 0.057** | | |
| | (0.025) | (0.025) | | |
| Rank, late (5th & 6th grades) | 0.061* | | | |
| | (0.035) | | | |

Notes: The table reports the results from regressions of a child being reported to be among the top 5 by achievement by her teachers in grade t+1 on classroom rank in grade t, controlling for a third-order polynomial in national achievement in math in grade t-1, and school-by-grade fixed effects, pooling across early (1st and 2nd), middle (3rd and 4th) and late (5th and 6th) grades. All regressions are limited to schools in which there are at least two classrooms per grade. Standard errors are clustered at the student level throughout. *Significant at 10%, **significant at 5%, ***significant at 1%.

Bottom 5

# Other outcomes

- We find positive effects of classroom rank in math on child happiness at the end of $1^{st}$ grade
- We find no effects of classroom rank in math on non-cognitive skills at the end of $6^{th}$ grade

# Conclusion

- We study the impact of classroom ability rank at the start of the academic year on learning during that year and in subsequent years
- Longitudinal study in elementary schools in Ecuador with random assignment of students to classrooms within school, in every grade
- Classroom rank in math positively affects achievement, more so in early grades, and its impact grows over time
- Exogenous changes in classroom rank in math improve executive function, teacher perceptions of student ability and child happiness

## Table: Child, teacher, and classroom characteristics

| | Mean | Standard deviation | N |
|---|---|---|---|
| Child and household characteristics | | | |
| Age of child (months) | 60.3 | 4.9 | 13,858 |
| Gender of child | 0.49 | 0.5 | 14,477 |
| Receptive vocabulary score (TVIP) | 83.3 | 16.9 | 13,733 |
| Mothers years of completed schooling | 8.8 | 3.8 | 13,627 |
| Fathers years of completed schooling | 8.5 | 3.8 | 10,594 |
| Mothers age | 30.2 | 6.6 | 13,637 |
| Fathers age | 34.6 | 7.9 | 10,620 |
| Proportion who attended preschool | 0.61 | 0.49 | 14,472 |
| Household has piped water in home | 0.83 | 0.38 | 14,407 |
| Household has flush toilet in home | 0.46 | 0.5 | 14,407 |
| Teacher and classroom characteristics | | | |
| Proportion female | 0.82 | 0.38 | 2830 |
| Proportion tenured | 0.82 | 0.38 | 2818 |
| Years of experience | 18.1 | 10.5 | 2820 |
| Class size | 36.2 | 6.4 | 2838 |

Notes: Table reports means and standard deviations of the characteristics of children entering kindergarten in 2012, measured at the beginning of the school year, and of the teachers they had between kindergarten and 6th grade. The TVIP is the *Test de Vocabulario en Imagenes Peabody*, the Spanish version of the Peabody Picture Vocabulary Test (PPVT). The test is standardized using the tables provided by the test developers which set the mean at 100 and the standard deviation at 15 at each age.

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Table: Testing for random assignment of children to classrooms

| | Kindergarten | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Grade 5 | Grade 6 |
|---|---|---|---|---|---|---|---|
| Test statistic | 1.359 | -0.383 | 0.905 | 0.3 | -0.445 | -0.222 | 0.98 |
| P-value | 0.174 | 0.702 | 0.366 | 0.764 | 0.657 | 0.825 | 0.327 |

Notes: In this table, we report results for tests of random assignment of children to classrooms within schools using a methodology proposed by Jochmans, 2020. The null hypothesis is absence of correlation between a childs ability measured at the end of the previous grade and the average ability of classroom peers assigned to her at the beginning of a given grade, conditional on school. The sample includes all children.

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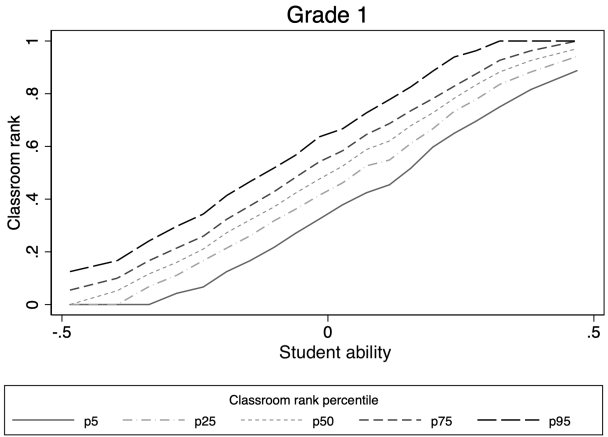
# Variation in classroom rank




Notes: We plot percentiles of classroom rank against student ability within school, measured as math ability rank at the national level, residualised of school fixed effects. We plot different percentiles of classroom rank within residualised national rank ventiles. For example, within the 10th ventile of national rank, classroom rank varies between 0.32 and 0.64.

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# Robustness checks

Table: Robustness checks, effects of math classroom rank on math achievement

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Panel A: Estimations with school-by-grade fixed effects | | | | | | |
| Classroom rank | 0.026*** | 0.042*** | 0.042*** | 0.026*** | 0.025*** | 0.032*** | 0.109*** |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.008) | (0.007) |
| School-by-grade fixed effects | X | X | X | X | X | X | X |
| Age and gender | | | | | X | | |
| | Panel B: Estimations with classroom-by-grade fixed effects | | | | | | |
| Classroom rank | 0.040*** | 0.063*** | 0.063*** | 0.040*** | 0.039*** | 0.040*** | 0.107*** |
| | (0.009) | (0.008) | (0.008) | (0.009) | (0.008) | (0.012) | (0.007) |
| Classroom-by-grade fixed effects | X | X | X | X | X | X | X |
| Age and gender | | | | | X | | |

Notes: The table reports estimates from regressions of national rank in math on classroom math rank. Observations are pooled across grades. All estimates include school-by-grade fixed effects. Column (1) reproduces the result from column (1) of Panel A in Table 4. In columns (2), (3), and (4), lagged achievement in math enters the regression as a linear term, quadratic term, or fourth-order polynomial (as opposed to a cubic term). Column (5) is comparable to column (1) but adds controls for child gender, age, and its square. In column (6) we use inverse probability weighting to correct for missing data. Column (7) corresponds to estimates of equation (**??**) in the main text. All regressions are limited to schools in which there are at least two classrooms per grade. Standard errors are clustered at the student level throughout. *Significant at 10%, **significant at 5%, ***significant at 1%. Back

# Teacher perceptions

Table: Effects of math classroom rank on teacher perceptions: bottom 5 student

| | Lags | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Rank, early (1st & 2nd grades) | -0.046** | -0.023 | -0.009 | -0.043** |
| | (0.022) | (0.021) | (0.021) | (0.021) |
| Rank, middle (3rd & 4th grades) | 0.011 | -0.002 | | |
| | (0.025) | (0.025) | | |
| Rank, late (5th & 6th grades) | -0.029 | | | |
| | (0.034) | | | |

Notes: The table reports the results from regressions of a child being reported to be among the bottom 5 by achievement by her teachers in grade t+1 on classroom rank in grade t, controlling for a third-order polynomial in national achievement in math in grade t-1, and school-by-grade fixed effects, pooling across early (1st and 2nd), middle (3rd and 4th) and late (5th and 6th) grades. All regressions are limited to schools in which there are at least two classrooms per grade. Standard errors are clustered at the student level throughout. *Significant at 10%, **significant at 5%, ***significant at 1%.

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