Classroom rank in mathematics and career choices

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Motivation

- Occupational choice has been shown to be an important factor for workers' welfare (e.g., job satisfaction and tenure, earnings, health outcomes)
  (e.g., Rose 2003; Zavodny 2003; Blau and Kahn 2016; Kelly et al. 2014; Strukik 2020)
- Various determinants of occupational choices have been identified:
  - Beliefs about employment probability, income potential, job characteristics
    (e.g., Reuben et al. 2017; Wiswall and Zafar 2018)
  - Cognitive and non-cognitive skills, social norms, family or school environment
    (e.g., Erosa et al. 2022; John and Thomsen 2015; Pallfy et al. 2022; Constant and Zimmermann 2003)
- School environment and occupational choices:
  - Teachers (Carell et al. 2010; Carlana 2019)
  - Classroom peers (Zölitz and Feld 2017; Jones and Kofoed 2020; Churad et al. 2022)
- In this study: Does classroom rank matter for occupational choices?

Why classroom rank might matter for occupational/career choices

- Rank affects intrinsic beliefs and behaviors
  (e.g., Elsner and Isphording 2017; Murphy and Weinhardt 2020; Delaney and Devereux 2022)
  - Students do not know their ability (Zafar 2011) and use peers to infer their ability
  - (Over-) confidence in ability may lead students' to exert more effort in studies -> Positive effects of true ability, grades, etc
- Actual (or perceived) ability in a particular subject gives students incentives to select into occupation that require skills in this subject
- If occupational choices are based on perceived (instead of actual) ability, are those choices efficient? (higher dropout rate, change of industry/field after initial choice)

This paper

- Studies impact of students' ordinal rank in math in the last year of compulsory school on subsequent occupational choices, further human capital investments and earnings
- Exploits differences in math achievements distributions across classrooms to identify effect of rank in classroom
- Idea: Compare students with same math ability but different classroom rank due to classroom assignment
- Data: Swiss PISA-2012 cohort linked to administrative student register data and earning records from 2012-2020

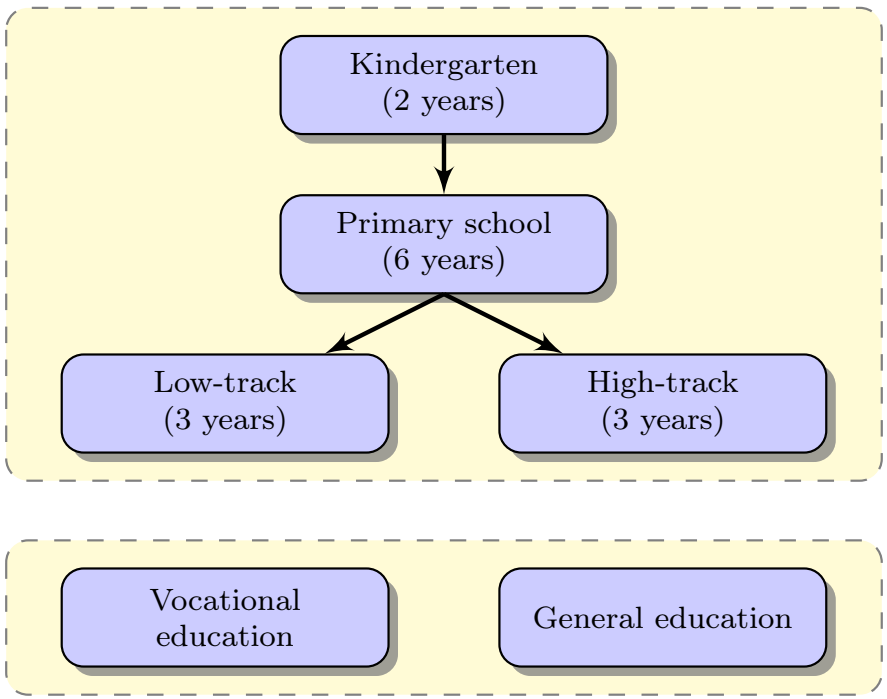
Findings

- **Effort provision:** Students with higher classroom rank in math are more interested in math, have a higher self-perception of their math ability, and provide higher effort studying math
- **Career choices:** Vocational education students with higher classroom rank in math are more likely to select into training occupations with higher STEM-Intensity
- **Earnings:** Students with higher classroom rank in math have higher earnings in the years after compulsory school -> consistent with STEM occupation providing better opportunities for higher-paid jobs
- **Occupation-Mismatch:** No evidence. Instead, rank associated with further educational investment in the educational field of the initial training occupation

$\rightarrow$ School environment has lasting effects on labor market outcomes

$\rightarrow$ No evidence that rank effect leads to inefficient occupational choices

Swiss education system (in a nutshell)



Compulsory school

Upper secondary school

Data

- Swiss section of PISA-2012 data (9th grader sample, ca. 12 000 observations)
  - Student assessment tests in math, science, and reading
- Linked with:
  - Administrative student register data, 2012-2020
    - E.g., enrollment status at any Swiss educational institution, type of VET program
  - Earning records from tax authorities, 2012-2020
    - E.g., employment status, monthly income
  - Novel data on skill requirements of training occupations
    - 4 skill requirement domains (math, natural science, language, foreign language), used to calculate STEM intensity of training occupations

Estimation model

- Compare students with same ability but different rank due to classroom assignment
- We estimate the equation:
  (e.g., Elsner and Isphording 2017; Murphy and Weinhardt 2020)

$$y_{ic} = \beta R_{ic} + f(A_{ic}) + \boldsymbol{\gamma^t X_{ic}} + \delta_c + \epsilon_{ic}$$

with

y_{ic}	:	(Long-term) outcome of student i in classroom c
R_{ic}	:	Percentile rank in classroom $R_{ic} \in (0,1)$
$f(A_{ic})$	:	Function of student i's ability in math, A_{ic}
$\boldsymbol{X_{ic}}$	:	Vector of students' background characteristics (e.g., age, sex, parental education, migrant, language spoken at home)
δ_c	:	Classroom fixed effects

Results: Effect of math rank on attitudes toward math

	Interested in math	Peers interested in math	Good at math	Provide effort in math
	(1)	(2)	(3)	(4)
Panel A				
Rank Math	0.237***	0.022	0.222***	0.121**
	(0.075)	(0.042)	(0.068)	(0.057)
Panel B				
Rank Math	0.198**	0.021	0.145**	0.125**
	(0.080)	(0.043)	(0.072)	(0.061)
Rank Science	0.022	-0.010	0.024	0.029
	(0.079)	(0.044)	(0.071)	(0.063)
Rank Reading	-0.032	-0.040	-0.019	-0.097
	(0.075)	(0.043)	(0.069)	(0.060)
Controls	Yes	Yes	Yes	Yes
Class FE	Yes	Yes	Yes	Yes
Observation	7,603	7,439	7,428	7,487
Cluster	490	490	490	490

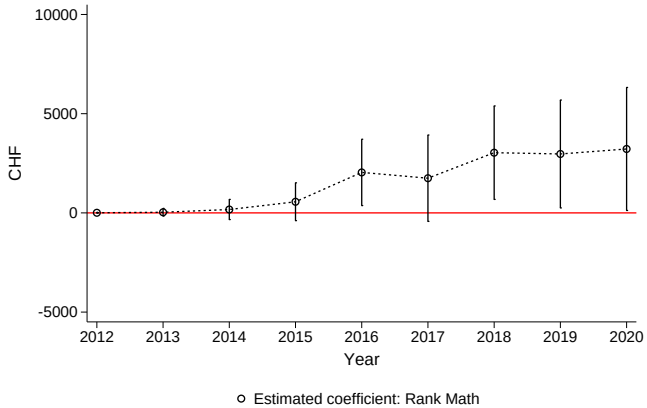
Note: Each column reports estimates of a separate regression of measure of math attitudes (measured between 0-4, not at all to very much) on students' classroom rank in math (Panel A) or math, reading, and science (Panel B). Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Panel A and D include additional control variables for students' PISA math test score (and squared term). D include additional control variables for students' PISA reading and science test scores (and squared term). Robust standard errors clustered at school-times-track-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Table All

Results: Effect of rank on STEM intensity of occupation

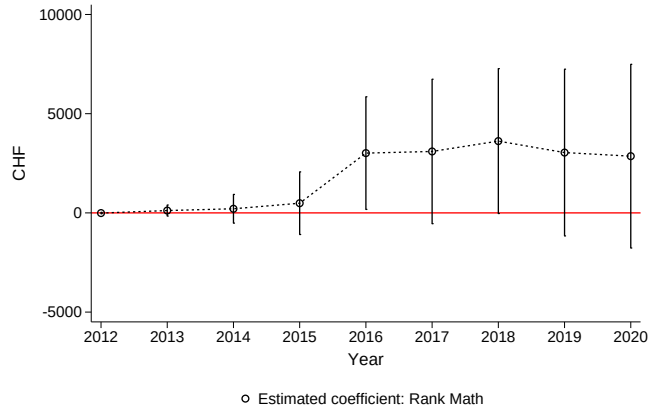
	(1)	(2)	(3)	(4)
STEM occupation				
Rank Math	0.088**			0.081*
	(0.039)			(0.042)
Rank Reading		0.011		-0.004
		(0.038)		(0.040)
Rank Science			0.022	-0.021
			(0.038)	(0.043)
Controls	Yes	Yes	Yes	Yes
Class FE	Yes	Yes	Yes	Yes
Observation	7,229	7,229	7,229	7,229
Cluster	483	483	483	483

Note: Each column reports estimates of separate regressions of a binary variable indicating if the STEM-intensity of a students' first training occupation lies in the 4th quarter of the STEM-intensity distribution of all training occupation on students' classroom rank in mathematics and/or science and/or reading (0-1, based on PISA scores) in the in the last year of compulsory school. Sample is restricted to students who start a vocational training program within 2 years after graduating from compulsory school. Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Robust standard errors clustered at school-times-track-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Table STEM intensity

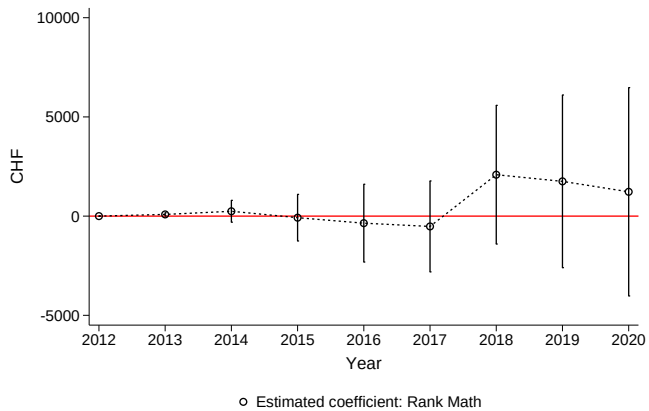
Results: Effect of math rank on earnings, 2012-2020



(a) 9th grader sample



(b) VE students



(c) GE students

Note: Each dot illustrates the coefficient estimates of classroom rank in math of separate regressions using yearly income as outcome variable for the entire sample (first row, 11684 observation), students who started a vocational track within 2 years after compulsory school (second row, 7229 observations), and students who started a general education track within 2 years after compulsory school but no vocational track (third row, 3717 observations). Classroom fixed effects, control variables, and PISA math score (and squared) included. Standard errors clustered at school-level. 90 % -confidence interval shown.

Results: Effect of math rank on earnings, 2016-2020

		Subsample	
	All	only VET	others
	(1)	(2)	(3)
Rank Math	13013.797**	15627.513*	1024.158
	(6110.185)	(9341.644)	(8545.368)
Controls	Yes	Yes	Yes
Class FE	Yes	Yes	Yes
Observation	11,684	7,229	4,455
Cluster	492	483	421

Note: Each column reports estimates of separate regressions of earnings in 2016-2020 on students' classroom rank in mathematics in the in the last year of compulsory school. Sample is restricted to students who start a vocational training program within 2 years after graduating from compulsory school. Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Robust standard errors clustered at school-times-track-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Table Rank Reading, Table Rank Science, Table Selection

Results: Effect of math rank on human capital investment by field

	Vocational Education	Vocational Education: Same occupation	Vocational Education: Other occupation	Professional	College
	(1)	(2)	(3)	(4)	(5)
A: Same field					
Rank Math	0.283**	0.103	0.180*	0.151**	-0.046
	(0.109)	(0.107)	(0.104)	(0.075)	(0.095)
B: Other field					
Rank Math	-0.060	0.001	-0.061	-0.017	-0.063
	(0.089)	(0.001)	(0.089)	(0.038)	(0.068)
Controls	Yes	Yes	Yes	Yes	Yes
Class FE	Yes	Yes	Yes	Yes	Yes
Observation	7,229	7,229	7,229	7,229	7,229
Cluster	483	483	483	483	483

Note: Each column reports estimates of separate regressions of years enrolled in a specific education program (see column title) between 2012-2020 on students' classroom rank in maths (0-1, based on PISA scores) in the in the last year of compulsory school. Panel A (B) reports estimates for years enrolled in a specific education program in the same (a different) field of education as the first training occupation. Sample is restricted to students who start a vocational training program within 2 years after graduating from compulsory school. Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Robust standard errors clustered at school-times-track-level Robust standard errors clustered at school-times-track-level. * p $<$ 0.1, ** p $<$ 0.05, *** p $<$ 0.01.

Conclusion

- We study the effect of classroom rank in math on subsequent occupational choices
- We find a positive effect of classroom rank in math on choosing a STEM occupation for a sample of vocational education students in Switzerland
- Classroom rank in math is also associated with higher incomes in the years after compulsory school (STEM occupation typically offer the opportunity to work in higher-paid jobs)
- We do not find that classroom rank is associated with a higher probability to re-train in a different field of education as their initial occupation (over-confidence does not seem to be problematic here)

Appendix

Results: Effect of math rank on attitudes toward math

	Interest in math	Math useful in future	Peers interested in math	Confident to solve math problems
	(1)	(2)	(3)	(4)
Panel A				
Rank Math	0.237***	0.052	0.022	0.050
	(0.075)	(0.079)	(0.042)	(0.047)
Panel B				
Rank Math	0.198**	0.018	0.021	0.008
	(0.080)	(0.085)	(0.043)	(0.050)
Rank Science	0.022	0.021	-0.010	0.018
	(0.079)	(0.077)	(0.044)	(0.044)
Rank Reading	-0.032	-0.026	-0.040	0.042
	(0.075)	(0.077)	(0.043)	(0.045)
Controls	Yes	Yes	Yes	Yes
Class FE	Yes	Yes	Yes	Yes
Observation	7,603	7,624	7,439	7,616
Cluster	490	490	490	491

Note: Each column reports estimates of a separate regression of measure of math attitudes (measured between 0-4, not at all to very much) on students' classroom rank in math (Panel A) or math, reading, and science (Panel B). Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Panel A and D include additional control variables for students' PISA math test score (and squared term). D include additional control variables for students' PISA reading and science test scores (and squared term). Robust standard errors clustered at school-times-track-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. go back

Results: Effect of math rank on attitudes toward math

	Good at math (5)	Anxious about math (6)	Perceived control (7)	Provide effort (8)
Panel A				
Rank Math	0.222***	-0.087	0.090*	0.121**
	(0.068)	(0.060)	(0.049)	(0.057)
Panel B				
Rank Math	0.145**	-0.076	0.088*	0.125**
	(0.072)	(0.065)	(0.053)	(0.061)
Rank Science	0.024	0.028	-0.009	0.029
	(0.071)	(0.064)	(0.052)	(0.063)
Rank Reading	-0.019	0.005	0.071	-0.097
	(0.069)	(0.061)	(0.049)	(0.060)
Controls	Yes	Yes	Yes	Yes
Class FE	Yes	Yes	Yes	Yes
Observation	7,428	7,561	7,544	7,487
Cluster	491	491	491	490

Note: Each column reports estimates of a separate regression of measure of math attitudes (measured between 0-4, not at all to very much) on students' classroom rank in math (Panel A) or math, reading, and science (Panel B). Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Panel A and D include additional control variables for students' PISA math test score (and squared term). D include additional control variables for students' PISA reading and science test scores (and squared term). Robust standard errors clustered at school-times-track-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. go back

Results: Effect of rank on STEM intensity of occupation

	(1)	(2)	(3)	(4)
A: STEM-intensity of occupation				
Rank Math	0.021**			0.014
	(0.010)			(0.011)
Rank Reading		0.011		0.007
		(0.009)		(0.010)
Rank Science			0.013	0.002
			(0.010)	(0.011)
B: STEM occupation (binary)				
Rank Math	0.088**			0.081*
	(0.039)			(0.042)
Rank Reading		0.011		-0.004
		(0.038)		(0.040)
Rank Science			0.022	-0.021
			(0.038)	(0.043)
Controls	Yes	Yes	Yes	Yes
Class FE	Yes	Yes	Yes	Yes
Observation	7,229	7,229	7,229	7,229
Cluster	483	483	483	483

Note: Each column reports estimates of separate regressions of a variable measuring the STEM-intensity of students' first training occupation (0-1, Panel A) or a binary variable indicating if the STEM-intensity of a students' first training occupation lies in the 4th quarter of the STEM-intensity distribution of all training occupation (Panel B) on students' classroom rank in mathematics and/or science and/or reading (0-1, based on PISA scores) in the in the last year of compulsory school. Sample is restricted to students who start a vocational training program within 2 after graduating from compulsory school. Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Robust standard errors clustered at school-times-track-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. go back

Effect of reading rank on earnings, 2016-2020

		Subsample	
	All	only VET	others
	(1)	(2)	(3)
Rank Reading	6028.707	6876.826	2245.031
	(5699.574)	(8805.185)	(8343.691)
Controls	Yes	Yes	Yes
Class FE	Yes	Yes	Yes
Observation	11,684	7,229	4,455
Cluster	492	483	421

Note: Each column reports estimates of separate regressions of earnings in 2016-2020 on students' classroom rank in mathematics in the in the last year of compulsory school. Sample is restricted to students who start a vocational training program within 2 after graduating from compulsory school. Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Robust standard errors clustered at school-times-track-level. * p $<$ 0.1, ** p $<$ 0.05, *** p $<$ 0.01. go back

Effect of science rank on earnings, 2016-2020

		Subsample	
	All	only VET	others
	(1)	(2)	(3)
Rank Science	7973.720	5431.180	3452.778
	(6023.044)	(9154.530)	(9264.008)
Controls	Yes	Yes	Yes
Class FE	Yes	Yes	Yes
Observation	11,684	7,229	4,455
Cluster	492	483	421

Note: Each column reports estimates of separate regressions of earnings in 2016-2020 on students' classroom rank in mathematics in the in the last year of compulsory school. Sample is restricted to students who start a vocational training program within 2 after graduating from compulsory school. Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Robust standard errors clustered at school-times-track-level. * p $<$ 0.1, ** p $<$ 0.05, *** p $<$ 0.01. go back

Effect of rank on immediate start of vocational education

	(1)	(2)	(3)	(4)
Rank Math	0.037			0.031
	(0.025)			(0.028)
Rank Reading		0.024		0.017
		(0.025)		(0.027)
Rank Science			0.017	-0.000
			(0.025)	(0.028)
Controls	Yes	Yes	Yes	Yes
Class FE	Yes	Yes	Yes	Yes
Observation	11,684	11,684	11,684	11,684
Cluster	492	492	492	492

Note: Each column reports estimates of a separate regression of a binary variable measuring if a student started VET within 2 years on students' classroom rank in mathematics and/or science and/or reading (0-1, based on PISA scores) in the year before starting the training occupation. Control variables: Gender, parental education, age, nationality, migration status, first language spoken at home, type of residence permit. Columns 1 and 4 include additional control variables for students' PISA math test score (and squared term). Columns 2 and 3 include additional control variables for students' PISA reading test score (and squared term). Columns 3 and 4 include additional control variables for students' PISA science test score (and squared term). Robust standard errors clustered at school-times-track-level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. go back