The Quality of Engineering Education in Russia and Elsewhere: **Very** Preliminary Results from an International Comparative Study

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- A major goal of university systems is to produce skilled graduates (Spellings, 2006; Alexander, 2000)
- Skilled graduates can contribute towards the productivity and innovation ➔ higher economic growth (Goldin and Katz, 2008; Autor et al., 2003; Bresnahan et al., 2002; Bresnahan, 1999; Katz and Krueger, 1998)
- Failing to produce skilled graduates may hinder the capacity of countries to compete in the global knowledge economy ➔ stifle growth (Hanushek and Woessman, 2012; Hanushek and Woessman, 2008)

What are the skills (competencies) that students are supposed to have learned during university?

- Academic skills such as math, science, language, major-specific skills (Pascarella & Terenzini, 2004)

- Higher order thinking skills such as critical thinking and creativity—perceived by employers to be among the most important skills for college graduates (ETS, 2013; AAC&U, 2011; Casner-Lotto and Barrington, 2006)

Although there is high and increasing interest from policymakers and researchers, few have examined whether students are learning these skills during university

- A couple of US studies show students make modest gains in academic and higher order thinking skills
  (Pascarella et al., 2011; Arum and Roska, 2011)

- There are very few international comparison studies (none of these studies use nationally representative samples)
  (Zlatkin-Troitschanskaia et al., 2014)

Policy discussion in the United States

*"**As other nations rapidly improve their higher education systems,** we are disturbed by evidence that the quality of student learning at U.S. colleges and universities is inadequate and, in some cases, declining."*

*"measure student learning using quality assessment data from instruments…the **growth of student learning** taking place in colleges"*

*"**assess** general education outcomes for undergraduates **in order to improve the quality of instruction and learning**."*

--Spellings Commission Report, 2006

What is the quality of engineering education in Russia?

- No consensus:
  - Russian engineering education is in the deep crisis (Pokholkov et al., 2012)
  - Employers believe that 40% of engineering graduates need retraining after graduation (Presidential Council for Science and Education, 2014)
  - Russian engineering education is of the highest quality and universities are competitive on the global scale (Aleksandrov et al., 2013)

- Most of the claims rely on experts’ evaluations, limited attempts to measure learning outcomes of students

Assessment of the quality of engineering education in Russia

- Current methods of assessing quality:
  - State: accreditation and licensing, monitoring of effectiveness, etc.
  - University rankings
  - Voluntary professional accreditation (Navodnov , 2013) and external program reviews (Bolotov et al. , 2013)

- Current assessments are very general:
  - focus on the quality of inputs and not outcomes
  - few measure skill levels and gains of students/graduates
  - do not examine which factors in higher education impact skill building

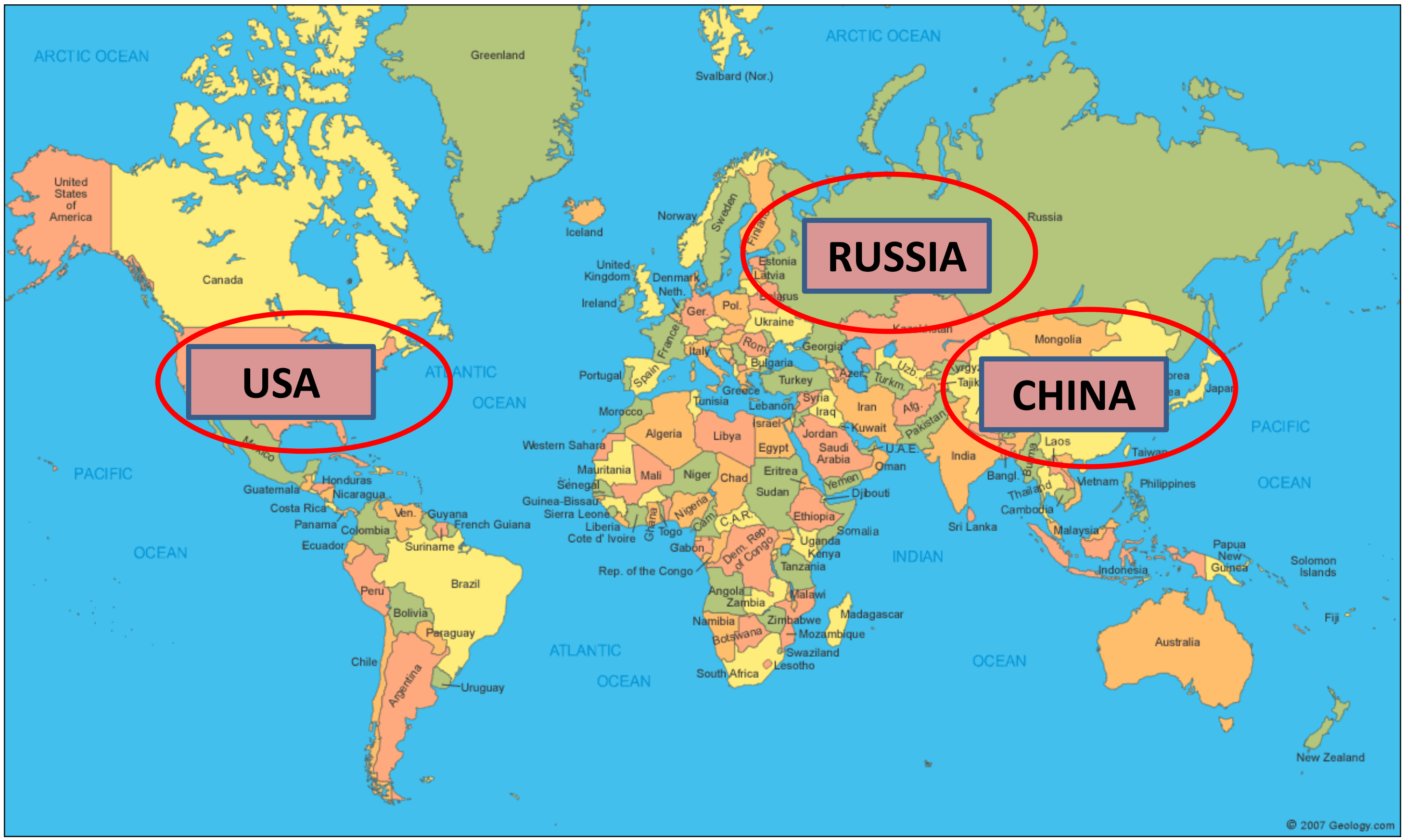
Our program - 2 main goals:

1) Assess and compare university student skills (levels and gains) within and across countries

2) Examine which types of factors (institutional, faculty, instructional, curricular, student behavior) help students develop skills

How to fulfill these goals?

Start by examining students in three of the world's largest economies:



How to fulfill these goals?

Extend the project to other countries

We are introducing other countries to the project

More specifically…

- Select a **nationally representative (random)** sample of universities and students in each country

- Focus on computing and engineering majors (CS/IT and EE)

- Assess skills over time
  - academic skills
  - higher order skills

- Survey students, professors, administrators

- Use *quasi-experimental* methods to find factors behind skill gains

3 stages of the project

Stage 1) Pilot Stage (Fall, 2014):

- Developing and validating assessments
- 10 institutions (~2,500 students) in China
- 10 institutions (~2,500 students) in Russia
- Institutions in US (data collected by ETS)

Pilot is Finished

3 stages of the project

Stage 2) Baseline Stage (Fall 2015):

- Nationally representative (random) sample of institutions (~10,000 grade 1 and 3 CS and EE students) in China
- Nationally representative (random) sample of institutions (~5,000 grade 1 and 3 CS and EE students) in Russia
- Institutions in the US (data collected by ETS)

Baseline is finished

Stage 3) Follow-up Stage (2016-2017):

- Same students (grade 2 and 4 students) in China
- Same students (grade 2 and 4 students) in Russia
- Institutions in the US (data collected by ETS)

First step: finding/creating the appropriate tests for computing and engineering majors

Academic tests

1. Math
2. Physics or basic computing
3. Major-specific knowledge (CS from ETS; EE under development)

Higher order thinking tests

1. Critical Thinking (ETS)
2. Quantitative Literacy (ETS)
3. Creativity
4. Ability to learn and make good choices

Tests should have the following properties

- Have desirable psychometric properties (reliability, validity, fairness, etc.)
- Can measure skill gains (growth in learning over time)
- Can measure and compare skill levels and gains across countries and across institutions within countries

Academic tests

Tests of math/physics/basic computing

- Given to students in the baseline and the follow-up (grade 2 students)
- Designed to test core math/science competencies that computing and engineering students learn in the first couple years of their programs
- In the follow-up, we will be able to measure absolute learning gains in these core areas

Tests of major-specific knowledge

- Given to grade 4 students in the follow up
- Designed to measure major-specific skill levels (for CS and EE) near the end of the undergraduate program

Higher order thinking tests

HEIghten tests from ETS
(critical thinking and quantitative literacy)

- Given to students in the baseline and the follow up
- In the follow-up survey, we will be able to measure learning gains in these skill areas

Other tests: Creativity

- Given to students in the baseline and follow up
- Measure of cognitive flexibility or divergent thinking (as opposed to problem-solving)
- Ask students to generate alternate uses for common objects such as a button or tire – assess how "creative" their uses are versus other test participants
- This type of creativity test has shown various forms of validity and has been used to assess the success of creativity training

Other tests:
Ability to learn and make good choices

- Premise: the fundamental goal of education is to prepare students to act independently in the world—which is to say, make good choices

- Use interactive assessments (digital technologies) to evaluate students in a context of choosing whether, what, how, and when to learn

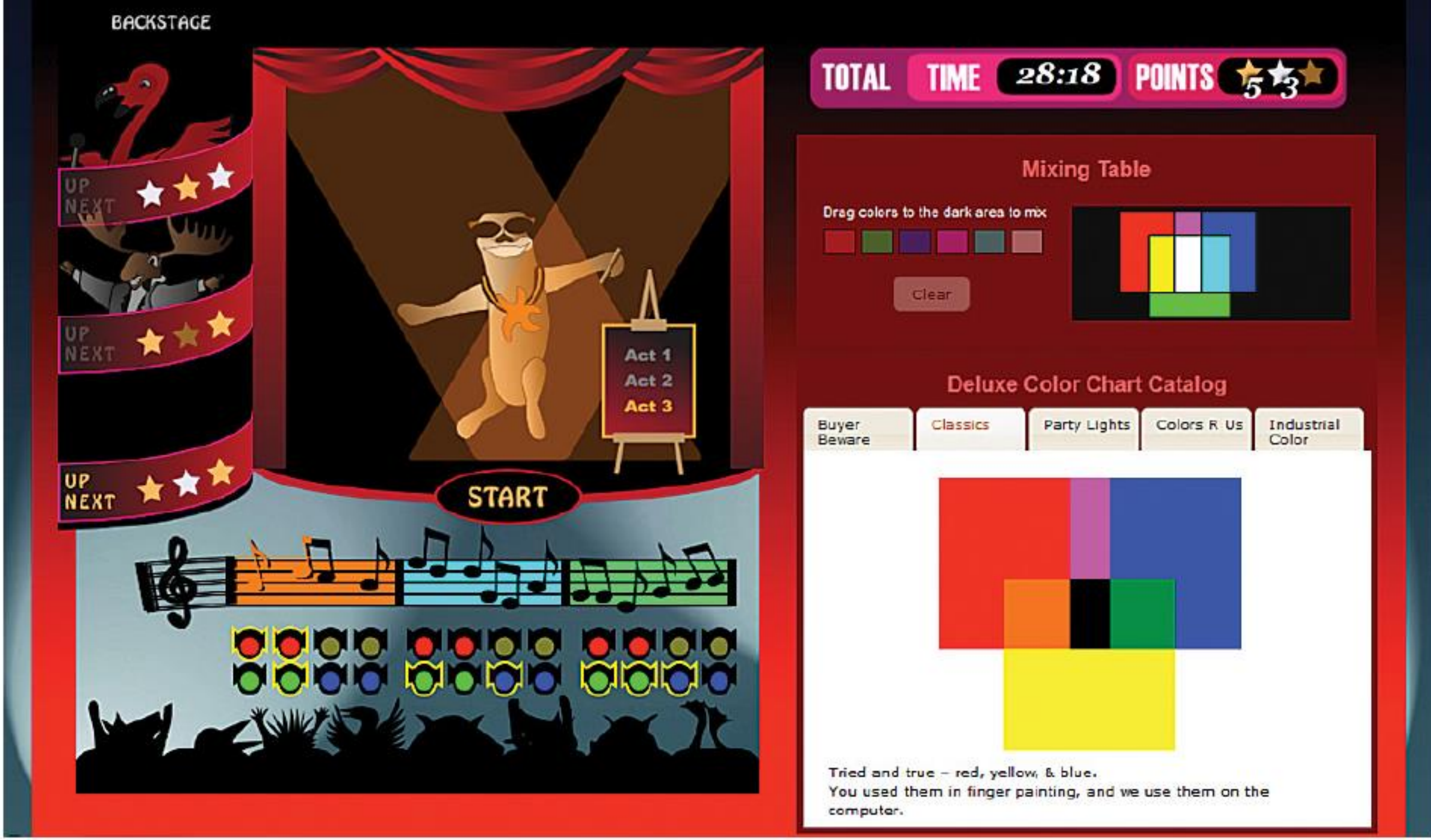

BACKSTAGE
TOTAL
TIME
28:18
POINTS
5
3
UP NEXT
UP NEXT
UP NEXT
Act 1
Act 2
Act 3
START
Mixing Table
Drag colors to the dark area to mix
Clear
Deluxe Color Chart Catalog
Buyer Beware
Classics
Party Lights
Colors R Us
Industrial Color
Tried and true – red, yellow, & blue.
You used them in finger painting, and we use them on the computer.

Illustration: creation of math and physics tests

Illustration: creation of the math/physics tests

1. Selected comparable EE and CS majors across China, Russia, and the United States
2. Selected content and sub-content areas in math and physics (*with experts*)
3. Collected and verified items (*with experts*)
4. Conducted a clinical pilot
5. Conducted a large pilot survey
6. Conducted psychometric analysis

1. Selected comparable EE and CS majors across China, Russia, and the United States

- Because EE/CS is divided into more specialized majors in China and Russia, we selected majors that have
  - consistent coursework/curricula across universities within each country
  - common core curricula between Russia and China
  - substantial overlap in coursework/curricula with EE/CS majors in the United States

Example

From China, we selected specialized EE majors such as

- Electrical Communications Engineering
- Electronic Information Science and Technology
- Etc.

that had the same core reqts. as EE majors in the US, e.g.:

- programming
- circuits
- analogue electronics
- signal processing and digital systems

Our comparison majors comparison table

	University		山东大学	西南交通大	北京工业大	合肥工业大	南京工业大	北京联合大	贵州大学科	清华大学	山东大学	合肥工业大	北京联合大	贵州大学科	山东大学
	Major CHN		电子信息工程	电子信息工程	电子信息工程	电子信息工程	电子信息工程	电子信息工程	电子信息工程	电子信息科学与技术	电子信息科学与技术	电子信息科学与技术	电子信息科学与技术	电子信息科学与技术	通信工程
	Major ENG		Eletronic and Information Engineering	Eletronic and Information Engineering	Eletronic and Information Engineering	Eletronic and Information Engineering	Eletronic and Information Engineering	Eletronic and Information Engineering	Eletronic and Information Engineering	Eletronic and Information Science and	Eletronic and Information Science and	Eletronic and Information Science and	Eletronic and Information Science and	Eletronic and Information Science and	Communication Engineering
	source		http://www.	http://dqxy.	http://wenk	http://www.36	http://jwc.njte	http://it.buu.ed	http://jobs.gzu	http://www.tsi	http://www.	http://ci.hfut.e	http://it.buu.ed	http://jobs.gzu	http://www.
	comments														
	Complete Curriculum (yes or no)		Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	Y
Physics	course 1 CHN	大学物理	6	8	8	Y	6.5			8	6	Y			6
	course 1 ENG	College Physics													
	course 2 CHN	量子与统计													1
	course 2 ENG	Quantum Mechanics and Statistical Physics													
	course 3 CHN	大学物理实验	1	2		Y	3.5			2	1	Y			1
	course 3 ENG	College Physics Experiment													
Mathematics	course 4 CHN	离散数学													
	course 4 ENG	Discrete Mathematics													
	course 5 CHN	复变函数与数理方程	3	3	3	Y	3		Y	3	3	Y		Y	3
	course 5 ENG	Functions of complex variables													
	course 6 CHN	微积分	10	10	11	Y	11			10	10	Y			10
	course 6 ENG	Calculus													
	course 7 CHN	线性代数	3	3	3	Y	2.5			6	3	Y			3
	course 7 ENG	Linear Algebra													
	course 8 CHN	概率论与随机过程	3	3	3	Y	3		Y	6	3	Y		Y	3
	course 8 ENG	Mathematical Statistics													
	course 9 CHN	计算机程序设计基础	3	3	3.5	Y	4			3	3	Y		Y	5
	course 9 ENG	Foundations in Programming (C Language)													
	course 10 CHN	数字逻辑与CPU基础（微机原理）	3	4		Y	3		Y	3	3	Y		Y	3
	course 10 ENG	Principles of Microcomputers (Digital Logic and CPU Foundamentals)													
	course 11 CHN	微机原理与接口技术			4		4								
	course 11 ENG	Principles of Microcomputer and Interface Technology													
	course 12 CHN	电子电路与系统基础(电路理论)	3.5	8	4.5	Y	5	Y	Y	4	3.5	Y	Y	Y	3.5
	course 12 ENG	Theory of Electrical Circuits													
	course 13 CHN	信号与系统	3.5	3.5	4	Y	4.5	Y	Y	4	3.5	Y	Y	Y	3.5
	course 13 ENG	Signals and Systems													
	course 14 CHN	电磁场/电动力学	3			Y	3	Y		3	3	Y	Y		3
	course 14 ENG	Electromagnetism													
	course 15 CHN	模拟电路	3	3	4	Y	4	Y	Y		3	Y	Y	Y	3
	course 15 ENG	Analogue Circuits													
	course 16 CHN	数字电路	3	3	3.5	Y	3.5	Y	Y	3	3	Y	Y	Y	3
	course 16 ENG	Digital Circuits													
	course 17 CHN	高频电路	3.5	2.5					Y		3.5				3.5
	course 17 ENG	High Frequency Circuits													
	course 18 CHN	数字信号处理	3.5	3	3.5	Y	3.5		Y		3.5	Y			3.5

2. Selected content and sub-content areas (*with experts*)

- We developed content maps in each subject that contain:
  - content areas taught in high school and in college in each country
  - the relative weight of the content areas in each country's national curriculum

- We conducted extensive interviews with 12 content experts in each country

- Experts adjusted the content maps to reflect what EE/CS students learn in each subject area (in each grade)

Selection of test content

English Description	Russia	China
Introduction to sets and their representation.	Y	Y
Relationship between different sets.	Y	Y
Computation of sets.	Y	Y
Functions. Representation of functions in graphs. The monotonic property.	Y	Y
Exponential functions.	Y	Y
Logarithmic functions.	Y	Y
Power functions.	Y	Y
Functions and solution to equations (roots). Logarithmic equations, exponential equations, power equations (quadratic).	Y	Y
Lines in cartesian space and their functions. Solution to a systems of linear equations.	Y	Y
Arbitrary angle and radian.	Y	Y
Trignometric functions. Cos, sin, tan.	Y	Y
Using the multiplication of vectors to deduce the cosine equation of the difference of two angles.	Y	Y
Using the cosine of the difference of two angles to deduce trignometric equations for sine and tangents.	Y	Y
Using cosine, sine, tangent equations to deduce double angle equation and similar equations.	Y	Y
Inequalities.	Y	Y
Quadratic inequalities.	Y	Y
Linear inequality with two unknowns. Linear programming.	Y	Y
The inequality sqrt(a*b)<(a+b)/2 (a,b>0)	Y	Y
Logical statements.	Y	Y
Fundamental logical connectives (operators).	Y	Y
Universal quantifier. Existential quantifier.	Y	Y
Plausible reasoning and deductive reasoning.	Y	Y
Direct and indirect proofs.	Y	Y
Mathematical induction.	Y	Y
Derivatives, their geometric illustration.	Y	Y
The calculation of derivatives.	Y	Y
The role of derivatives in studying functions and their properties.	Y	Y
Optimization problems and their application.	Y	Y
Introduction to definite integrals. The fundamental theorem of calculus.	Y	Y
Random sampling.	Y	Y
Using samples to estimate the population.	Y	Y
The correlation between two random variables.	Y	Y
Probility and frequency.	Y	Y
Mutually exclusive events.	Y	Y
Classical probability.	Y	Y

Test	Number of content areas	Number of sub-content areas
Math, grade 1	8	36
Math, grade 3	10	116
Physics, grade 1	10	49
Physics, grade 3	10	104

Expert questionnaire (Russia)

Номер	Раздел	Sub-topics (ENG)	Тема	Важность 1= Не важно 2= Отчасти важно 3= Важно 4= Очень важно 5= Совершенно необходимо	Эту тему изучают 1=Только в средней школе 2= Только в вузе 3= В вузе и средней школе 4= Ни в школе, ни в вузе	Если тему изучают в вузе, то на каком году обучения это происходит?	Пожалуйста, опишите тему как ее проходят в вузе, если ее изучают и в средней школе, и в вузе
1	Функции и области их определения	Introduction to sets and their representation.	Введение в теорию множеств и их представление				
2	Функции и области их определения	Relationship between different sets.	Отношения между множествами				
3	Функции и области их определения	Computation of sets.	Вычисление множеств				
4	Функции и области их определения	Functions. Representation of functions in graphs. The monotonic property.	Функции. Графики функций. Свойство монотонности функций				
5	Функции и области их определения	Exponential functions.	Показательные функции				
6	Функции и области их определения	Logarithmic functions.	Логарифмические функции				

3. Collected and verified items (*with experts*)

- We collected existing test items that fairly reflected the content areas in the content map (from multiple sources from the China, Russia, and the United States)

After collecting the items, we verified them:

Step 1: Translation and back translation*

- Translated items were back translated into English.
- Experts were asked to compared back translated versions to the original items and see if there was any discrepancy in meaning.

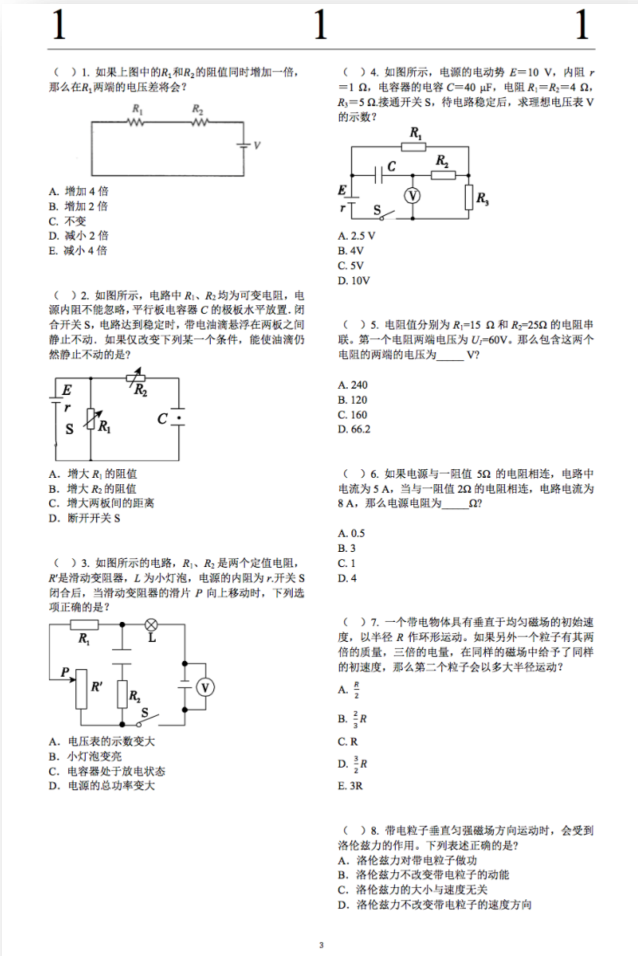
Step 2: To make sure the items were valid, relevant, clear, and of suitable difficulty, we interviewed 12 more experts from each country

Expert questionnaire (Russia)

№	ID задания и Предметная область	Задание	Понятно ли сформулировано задание? 1 = ДА 2 = НЕТ, пожалуйста, уточните что именно	Насколько хорошо это задание позволяет оценить предметную область? 1 = Очень хорошо 2 = Хорошо 3 = Более-менее хорошо 4 = Плохо X = Это задание не соответствует тому, что изучают студенты в данной предметной области	Оцените сложность задания 1 = Легкое (75-100% студентов смогут ответить) 2 = Среднее (50-74%) 3 = Сложное (25-49%) 4 = Очень сложное (0-24%)	Какое время затратит средний студент на выполнение этого задания? 1 = менее 30 секунд 2 = 0.5 - 1 мин. 3 = 1 - 2 мин. 4 = 2 - 3 мин. 5 = более 3 минут
1	mc03101 | Производные и их применение	Если $f(x) = xe^x$, то что из перечисленного верно? A. При $x = 1$ функция $f(x)$ достигает максимума. B. При $x = 1$ функция $f(x)$ достигает минимума. C. При $x = -1$ функция $f(x)$ достигает максимума. D. При $x = -1$ функция $f(x)$ достигает минимума.				
2	mc03102 | Производные и их применение	Если $f(x) = \frac{2}{x} + \ln x$, то что из перечисленного верно? A. При $x = \frac{1}{2}$ функция $f(x)$ достигает максимума. B. При $x = \frac{1}{2}$ функция $f(x)$ достигает минимума. C. При $x = 2$ функция $f(x)$ достигает максимума. D. При $x = 2$ функция $f(x)$ достигает минимума.				
3	mc03103 | Производные и их применение	На каком интервале функция $f(x) = \frac{1}{2}x^2 - \ln x$ убывает? A. $(-1, 1)$ B. $(0, 1)$ C. $[1, +\infty]$ D. $(0, +\infty)$				

We used the verified items to create the clinical pilot tests

Physics



1 1 1

（ ）1. 如果上图中的R_1和R_2的阻值同时增加一倍，那么在R_1两端的电压差将会？

A. 增加 4 倍
B. 增加 2 倍
C. 不变
D. 减小 2 倍
E. 减小 4 倍

（ ）2. 如图所示，电路中 R_1、R_2 均为可变电阻，电源内阻不能忽略，平行板电容器 C 的极板水平放置. 闭合开关 S，电路达到稳定时，带电油滴悬浮在两板之间静止不动. 如果仅改变下列某一个条件，能使油滴仍然静止不动的是?

A. 增大 R_1 的阻值
B. 增大 R_2 的阻值
C. 增大两板间的距离
D. 断开开关 S

（ ）3. 如图所示的电路，R_1、R_2 是两个定值电阻，R'是滑动变阻器，L 为小灯泡，电源的内阻为 r.开关 S 闭合后，当滑动变阻器的滑片 P 向上移动时，下列选项正确的是？

A. 电压表的示数变大
B. 小灯泡变亮
C. 电容器处于放电状态
D. 电源的总功率变大

（ ）4. 如图所示，电源的电动势 E=10 V，内阻 r=1 Ω，电容器的电容 C=40 μF，电阻 $R_1=R_2$=4 Ω，R_3=5 Ω.接通开关 S，待电路稳定后，求理想电压表 V 的示数？

A. 2.5 V
B. 4V
C. 5V
D. 10V

（ ）5. 电阻值分别为 R_1=15 Ω 和 R_2=25Ω 的电阻串联。第一个电阻两端电压为 U_1=60V。那么包含这两个电阻的两端的电压为_____ V?

A. 240
B. 120
C. 160
D. 66.2

（ ）6. 如果电源与一阻值 5Ω 的电阻相连，电路中电流为 5 A，当与一阻值 2Ω 的电阻相连，电路电流为 8 A，那么电源电阻为_____Ω?

A. 0.5
B. 3
C. 1
D. 4

（ ）7. 一个带电物体具有垂直于均匀磁场的初始速度，以半径 R 作环形运动。如果另外一个粒子有其两倍的质量，三倍的电量，在同样的磁场中给予了同样的初速度，那么第二个粒子会以多大半径运动？

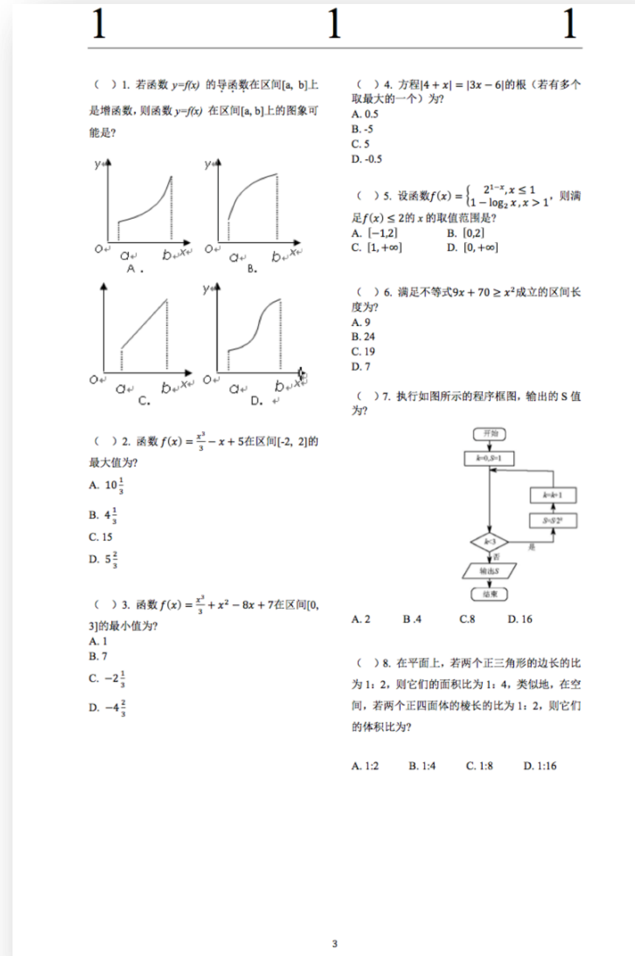
A. $\frac{R}{2}$
B. $\frac{2}{3}R$
C. R
D. $\frac{3}{2}R$
E. 3R

（ ）8. 带电粒子垂直匀强磁场方向运动时，会受到洛伦兹力的作用。下列表述正确的是?

A. 洛伦兹力对带电粒子做功
B. 洛伦兹力不改变带电粒子的动能
C. 洛伦兹力的大小与速度无关
D. 洛伦兹力不改变带电粒子的速度方向

3

Math



1 1 1

（ ）1. 若函数 $y=f(x)$ 的导函数在区间[a, b]上是增函数，则函数 $y=f(x)$ 在区间[a, b]上的图象可能是?

（ ）2. 函数 $f(x)=\frac{x^3}{3}-x+5$在区间[-2, 2]的最大值为?

A. $10\frac{1}{3}$
B. $4\frac{1}{3}$
C. 15
D. $5\frac{2}{3}$

（ ）3. 函数 $f(x)=\frac{x^3}{3}+x^2-8x+7$在区间[0, 3]的最小值为?

A. 1
B. 7
C. $-2\frac{1}{3}$
D. $-4\frac{2}{3}$

（ ）4. 方程$|4+x|=|3x-6|$的根（若有多个取最大的一个）为?

A. 0.5
B. -5
C. 5
D. -0.5

（ ）5. 设函数$f(x)=\begin{cases}2^{1-x}, x\le 1\\ 1-\log_2 x, x>1\end{cases}$，则满足$f(x)\le 2$的 x 的取值范围是?

A. $[-1,2]$ B. $[0,2]$
C. $[1,+\infty]$ D. $[0,+\infty]$

（ ）6. 满足不等式$9x+70\ge x^2$成立的区间长度为?

A. 9
B. 24
C. 19
D. 7

（ ）7. 执行如图所示的程序框图，输出的 S 值为?

A. 2 B .4 C.8 D. 16

（ ）8. 在平面上，若两个正三角形的边长的比为 1：2，则它们的面积比为 1：4，类似地，在空间，若两个正四面体的棱长的比为 1：2，则它们的体积比为?

A. 1:2 B. 1:4 C. 1:8 D. 1:16

3

4. Conducted a Clinical pilot

We checked the clinical pilot tests for language ambiguity, formatting, etc…

We did this by giving the clinical pilot test to

- 40 grade 1 students
- 40 grade 3 students

(in each country)

Clinical Pilot

Pilot tests

- Based on the clinical pilot we created the pilot tests (45 items per test)

5. Conducted a large pilot survey

- 11 Chinese universities, 10 Russian Universities
- 2,726 students in China and 2,753 students in Russia
- We also gave students a short questionnaire asking them about their background (gender, rural-urban status, age etc.)

6. Conducted psychometric analysis

Experts on our team analyzed the pilot data to create final tests with the right properties:

- Reliability
- Validity
- Dimensionality
- Vertical-scalability (across grades)
- Comparability (across countries)
- Fairness
- Etc.

Translation of Tests

- We used CAPSTAN to translate the ETS tests into Chinese and Russian

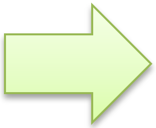
- CAPSTAN is the linguistic quality control agent for OECD's PISA and AHELO tests, TIMSS, etc.

cApStAn™

LINGUISTIC QUALITY CONTROL

Electronic Administration of Tests

- We used an ***efficient and flexible*** software to administer the tests electronically
- The software platform ***randomly*** assigns students to receive different combinations of test forms and ensures ***comparability*** across students, institutions and countries




Technical support

- We built a ***technical support team*** to handle country-specific IT issues

- There were network and IT differences across universities – we needed 24 hour software and network support across time zones

Training Proctors

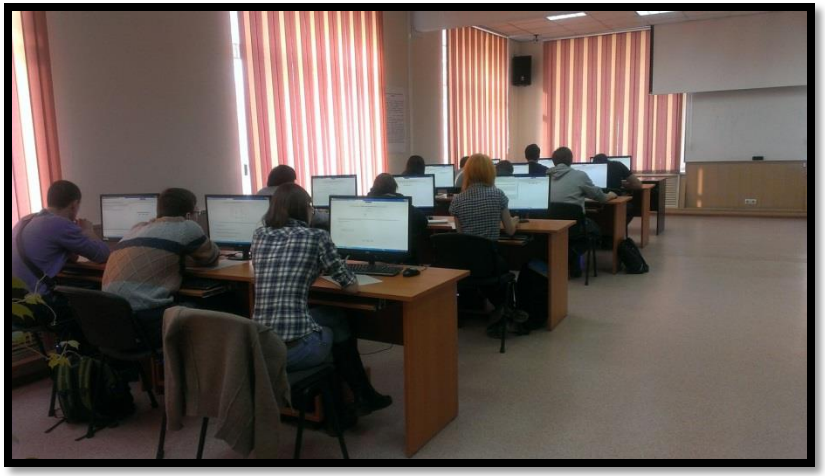
China

Russia

Extensive Piloting

China

Russia



Incentives to help students and universities take low-stakes tests seriously

Experiment

In our pilot phase, we conducted a “randomized experiment” to see if students would score differently if they were incentivized to take the exam more seriously

Students were randomly assigned to receive 1 of 4 different test forms, each with a different informational prompt

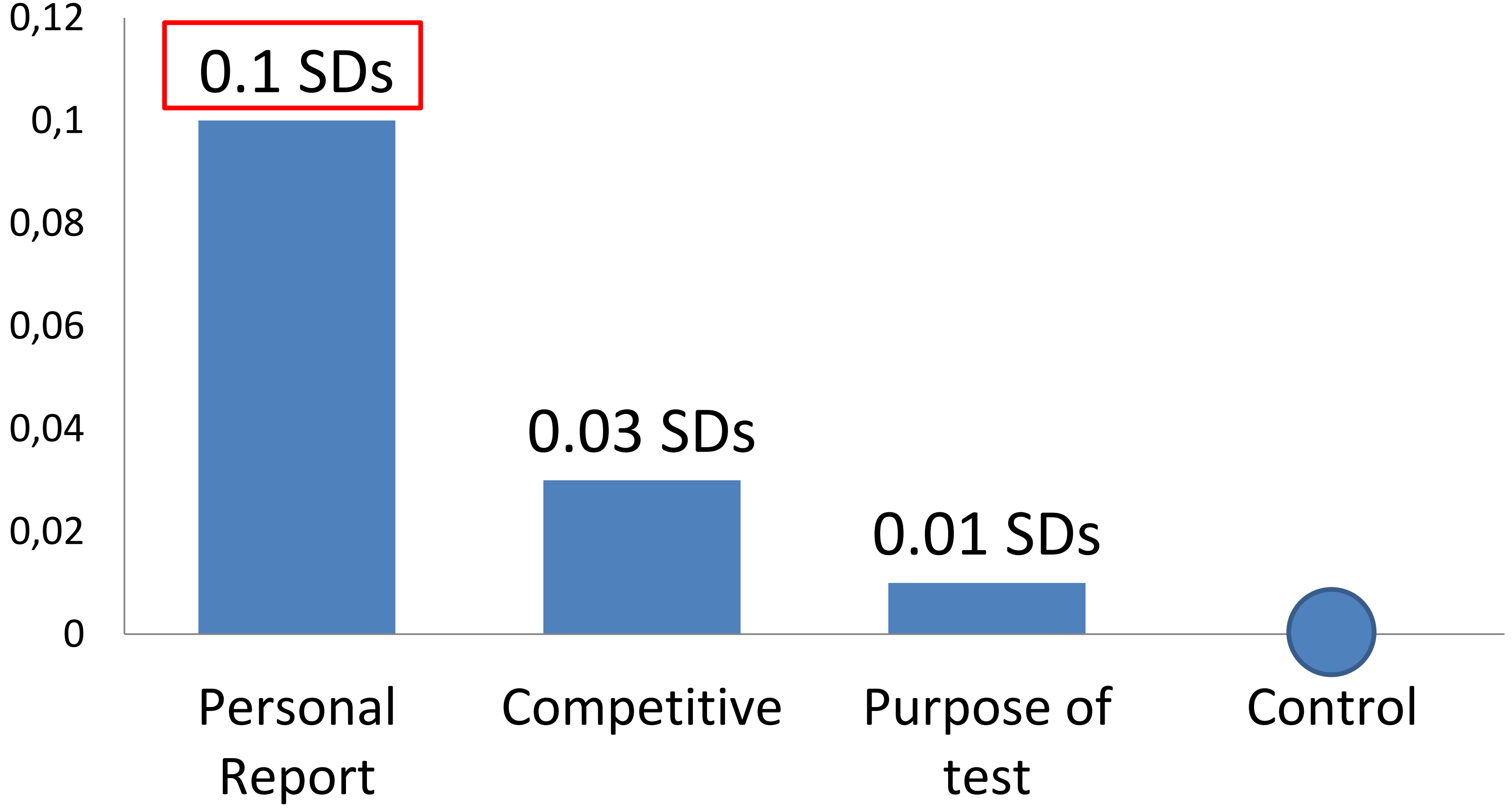
- ***Personal-report prompt***: “Please indicate whether you would like us to provide you with a report of your test results”

- ***Competitive prompt***: “The test you are taking will be used to compare the quality of your university with that of other universities in your country”

- ***Purpose-of-test prompt***: “The test you are taking seeks to measure your skills in critical thinking. Critical thinking is XXXXX.”

- ***No prompt***

Results of the experiment



- Only one of the prompts (***personal-report***) significantly improved student test scores

- In our baseline and follow-up stages, we now offer students the option of receiving a personalized report of how they did on their exams. We also provide reports to universities.

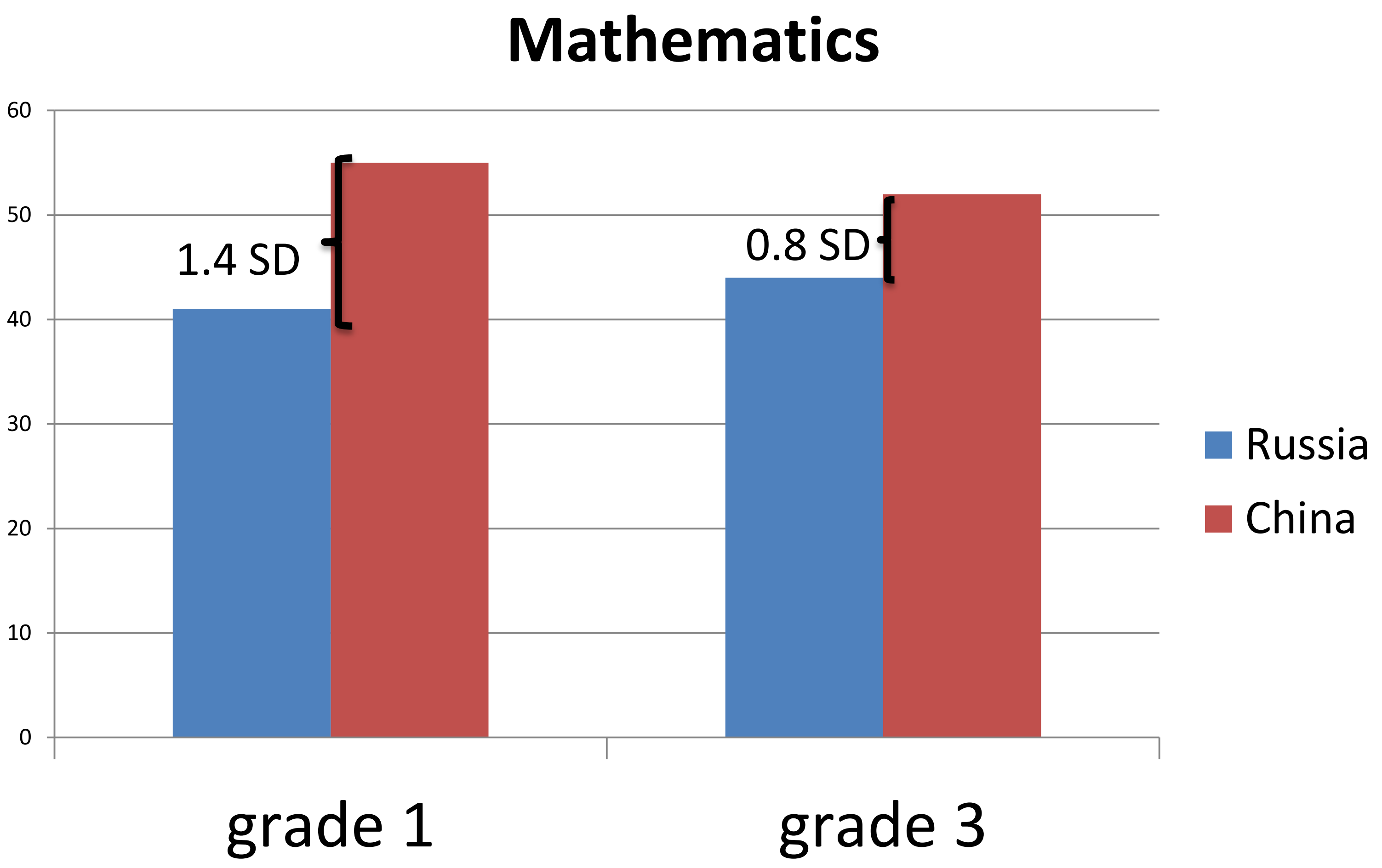
Results from the Baseline

How do university students compare ACROSS countries?

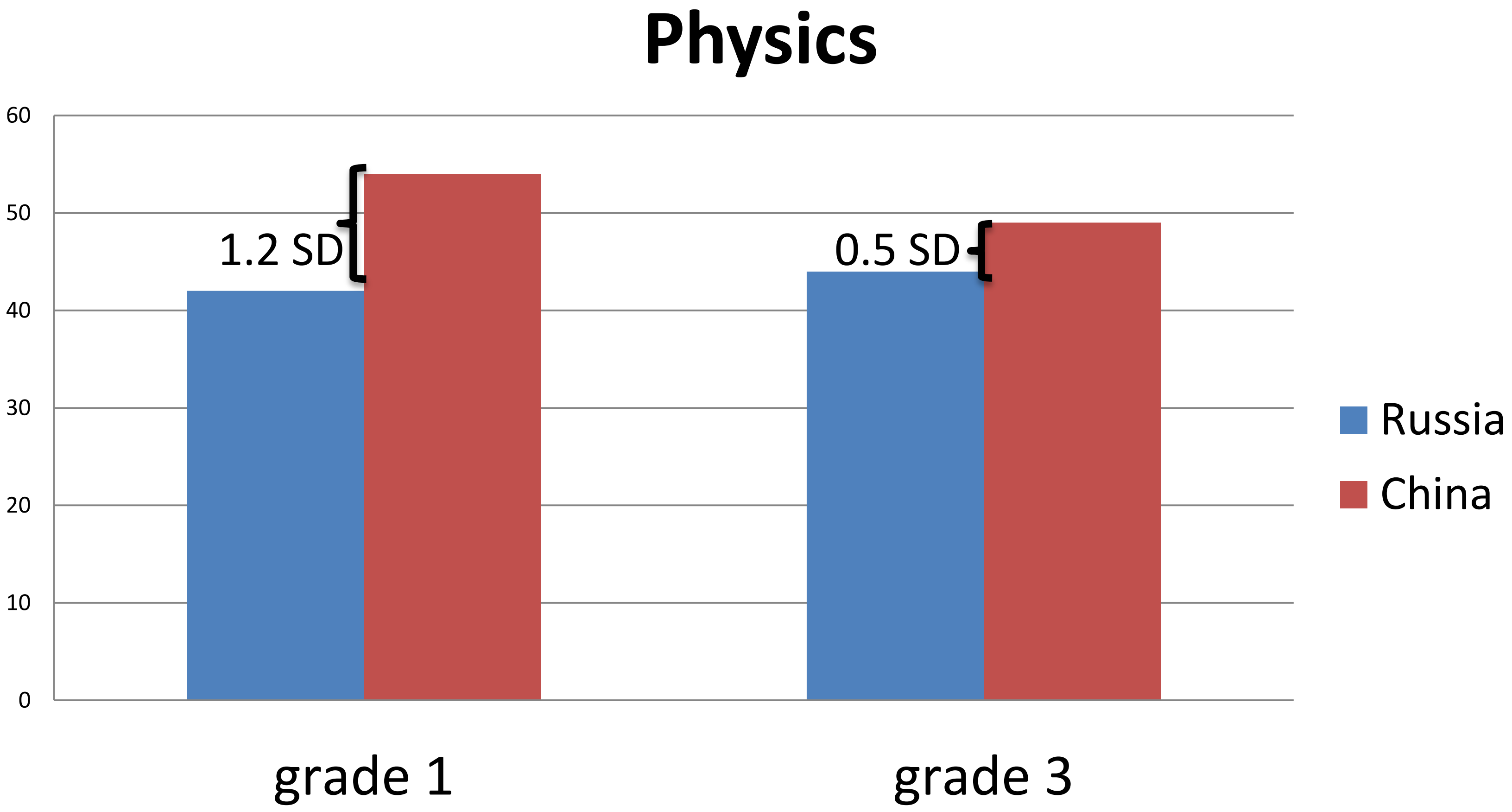
1. *Academic Skills (math and physics)*
2. *Critical Thinking (ETS PP)*

Academic Skills – Baseline Results

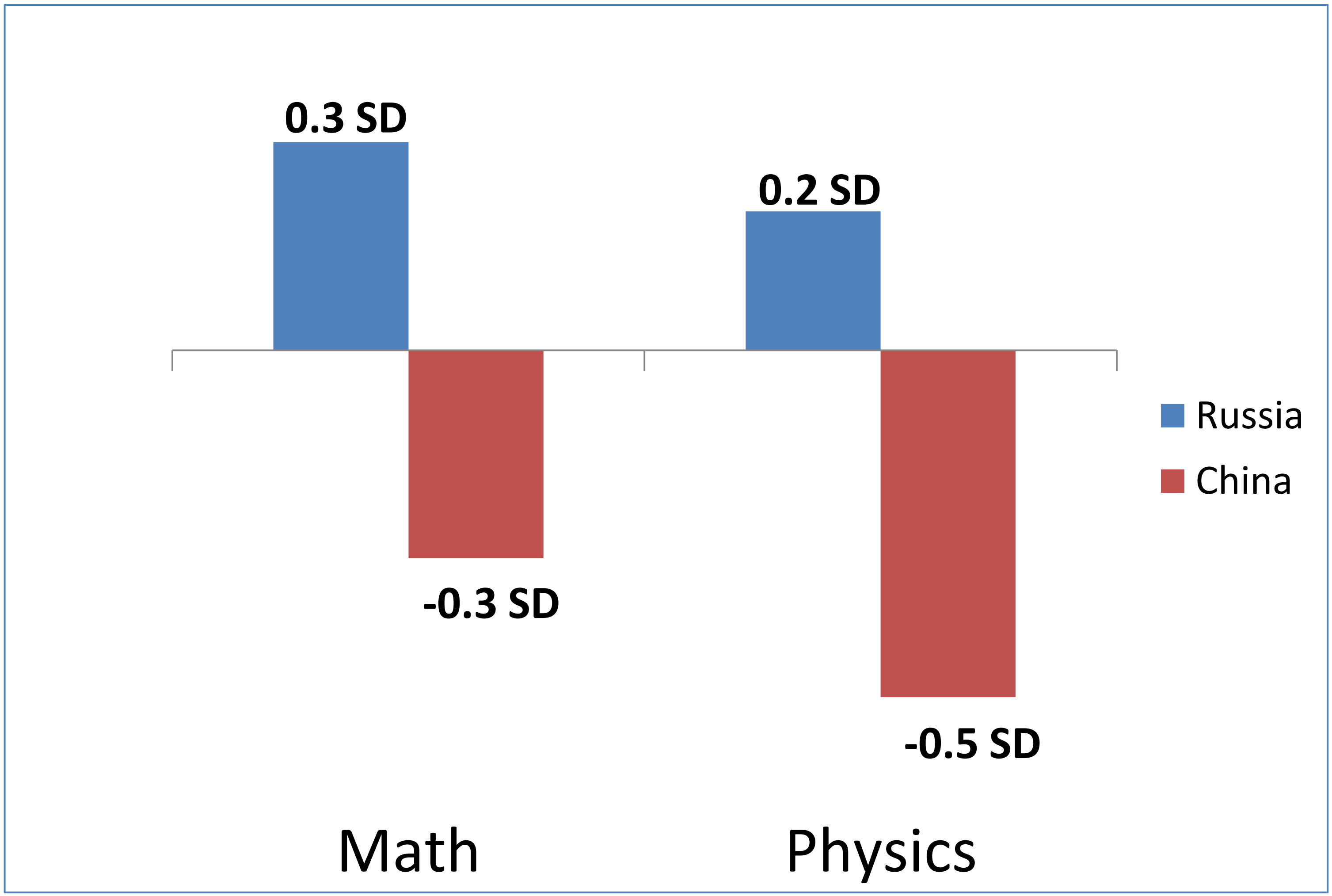
BASELINE
Comparison of academic skills across countries



BASELINE
Comparison of academic skills across countries



Gains from grade 1 to grade 3



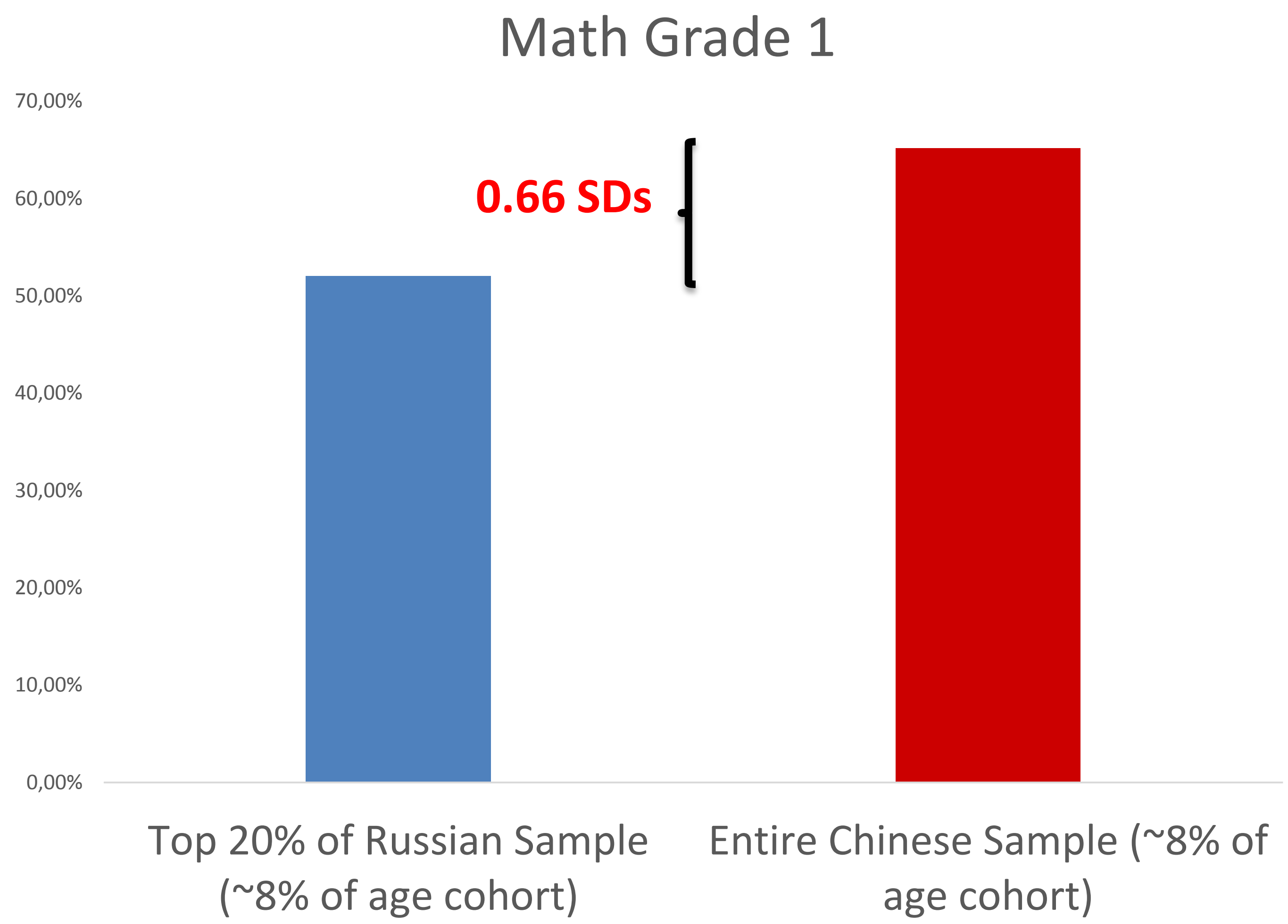
Comparison of academic skills across countries

- China's entering freshman (among top 8% of the cohort) have MUCH higher levels of math/physics skills than Russia (among top 40% of the cohort)

- China's juniors still have higher levels of math/physics skills than Russia

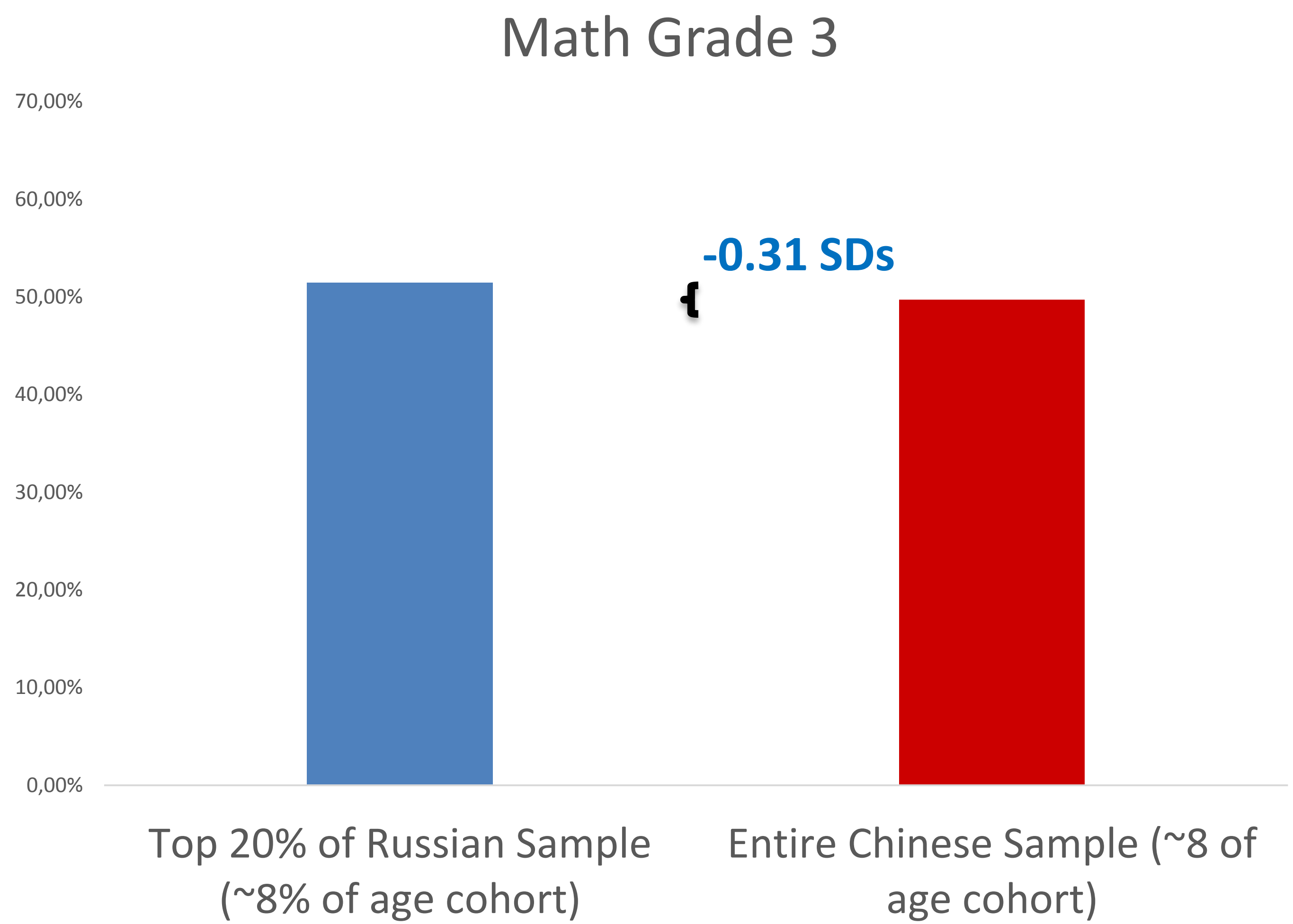
- **HOWEVER,** while students in China make **NO** (or negative) progress in math/physics from their freshman to junior years, students in Russia make progress* (*with one caveat - **dropouts**)

What happens if we compare Russia’s top 8% to China’s top 8%?

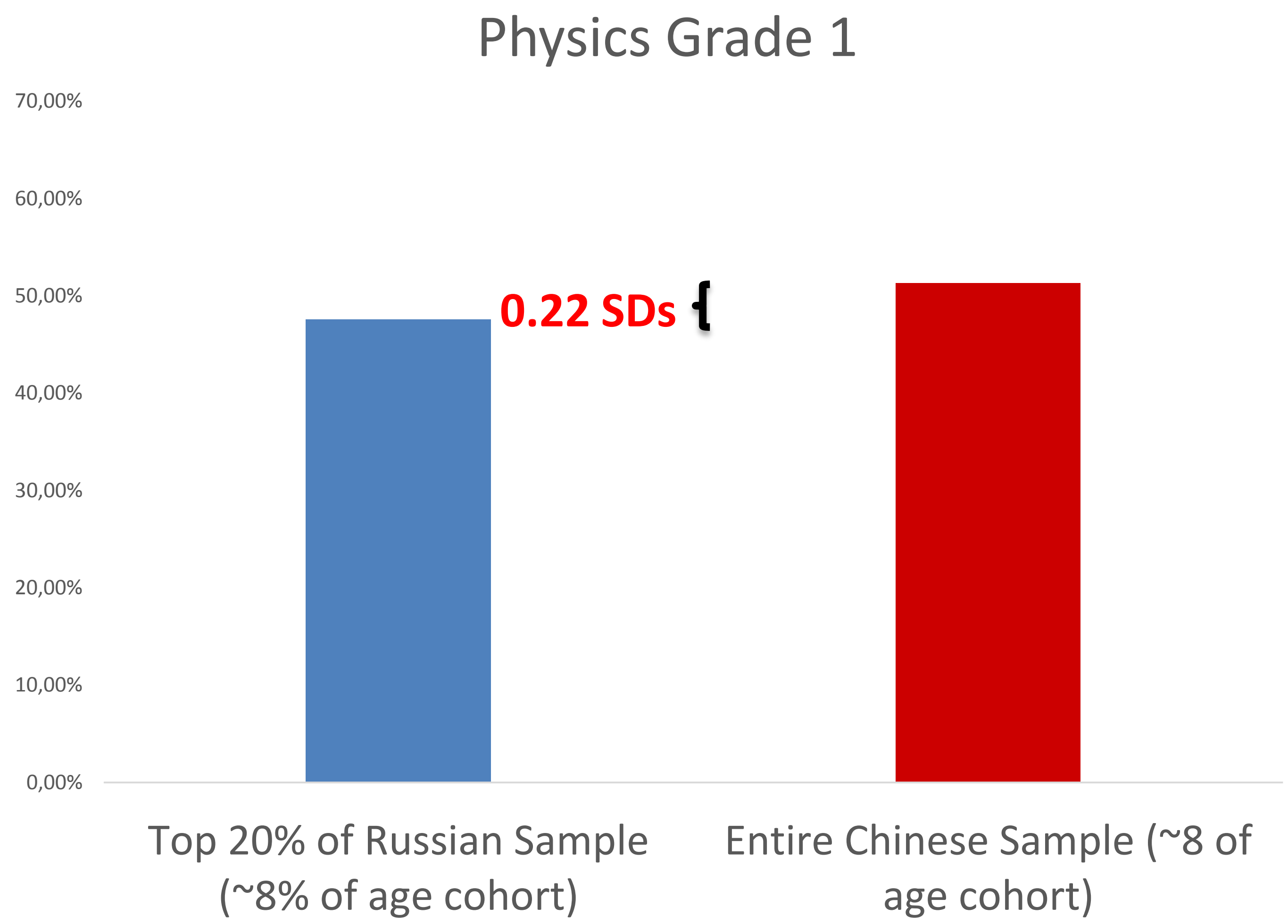


Math Grade 1
70,00%
60,00%
50,00%
40,00%
30,00%
20,00%
10,00%
0,00%
0.66 SDs
Top 20% of Russian Sample (~8% of age cohort)
Entire Chinese Sample (~8% of age cohort)

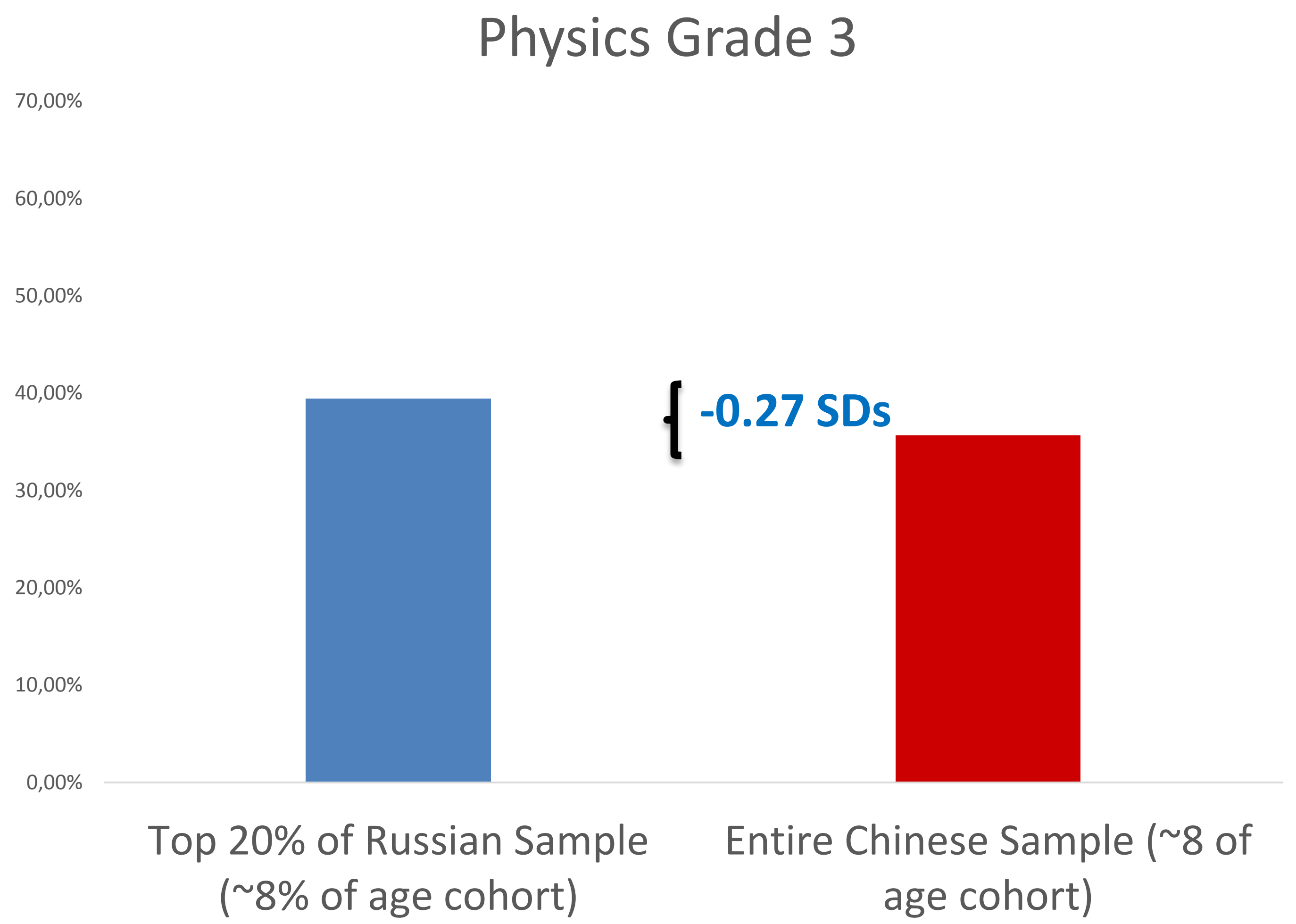
By grade 3, Russian scores are higher



Same story for physics…



By grade 3, Russian scores are higher



How might we interpret each set of estimates?

The virtue in comparing entire samples?

- China produces 4 times as many engineers as Russia and there is a global market for engineers:
  - China has higher levels of learning even after 2 years of college…

- China’s K-12 system is producing a remarkably high level of skills for college entrants. Lessons to learn from China, if any?

- The reduction in the gap in gains between the two countries is in part due to China’s “negative” learning in higher education. What happens if China takes higher education more seriously?

The virtue in comparing top 8%s?

- Top students in Russia are not too far behind top students in China from the start and are making definite strides in learning…

…while top students in China are certainly NOT

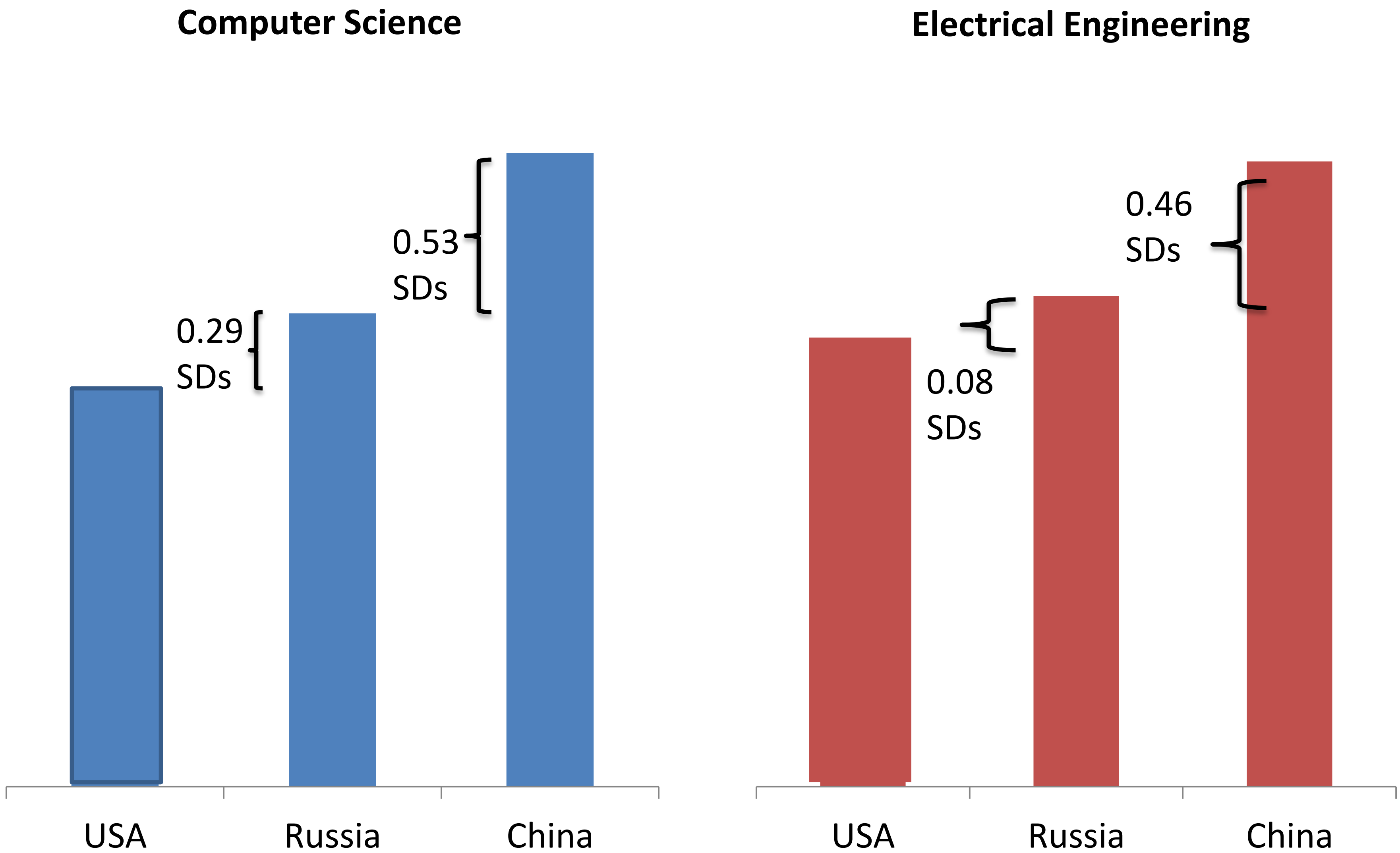
- Remember, we did not adjust for dropout (but dropout should be less for top 8% in Russia)

How do university students compare ACROSS countries?

1. *Academic Skills*
2. *Critical Thinking*

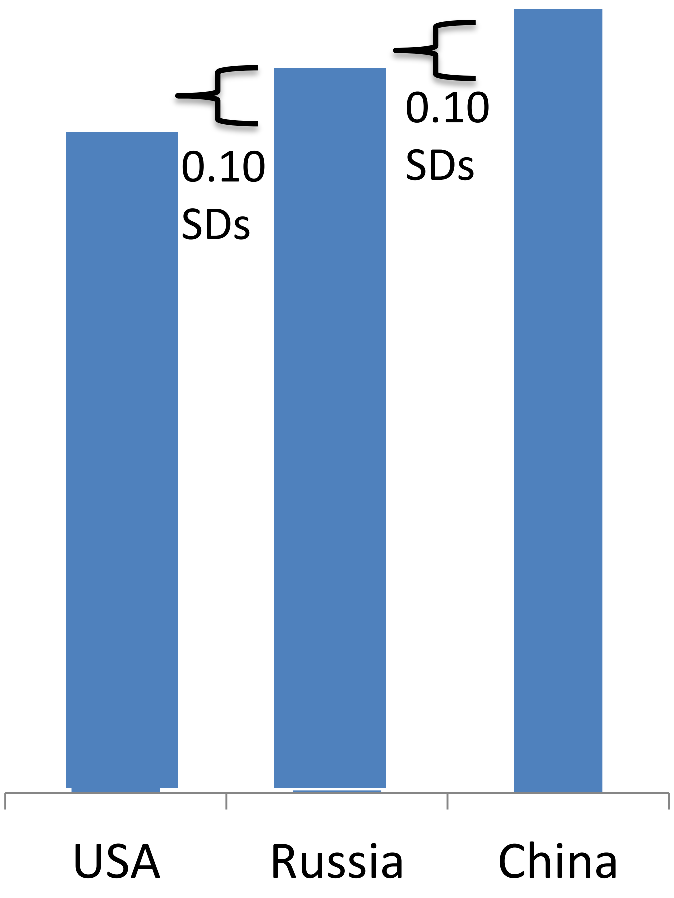
Critical Thinking Skills – Pilot Results

PILOT
Comparison of Critical Thinking Skill Levels Across Countries (Entering Freshmen)

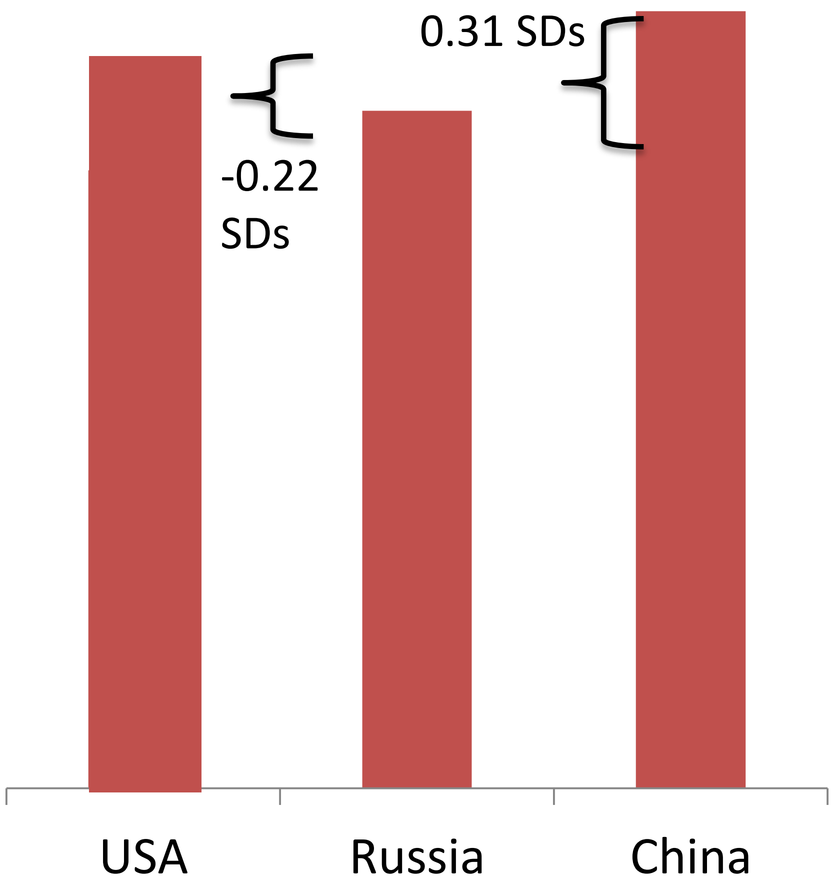


PILOT
"RAW" Comparison of Critical Thinking Skill Levels Across Countries (Juniors)

Computer Science

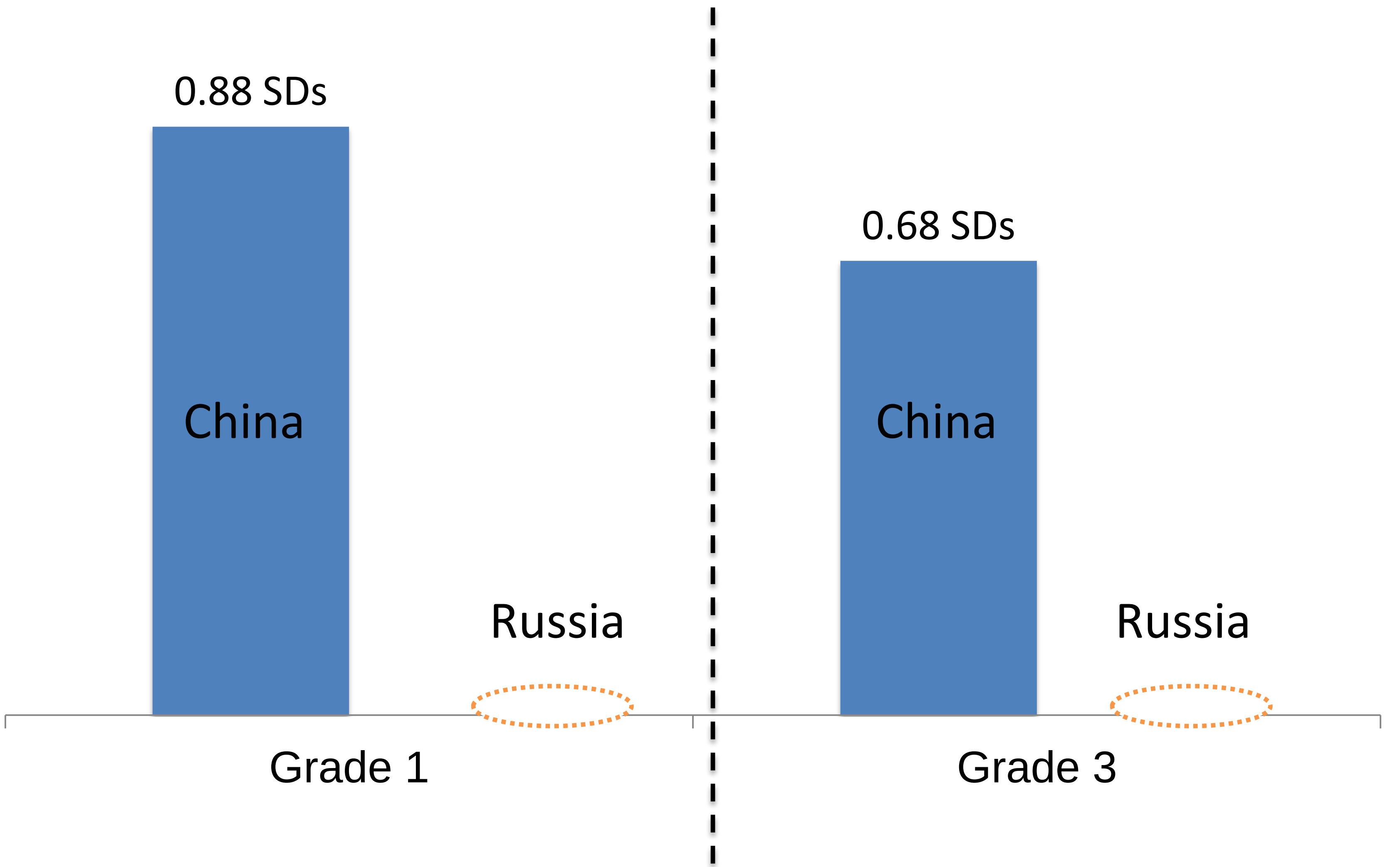


Electrical Engineering

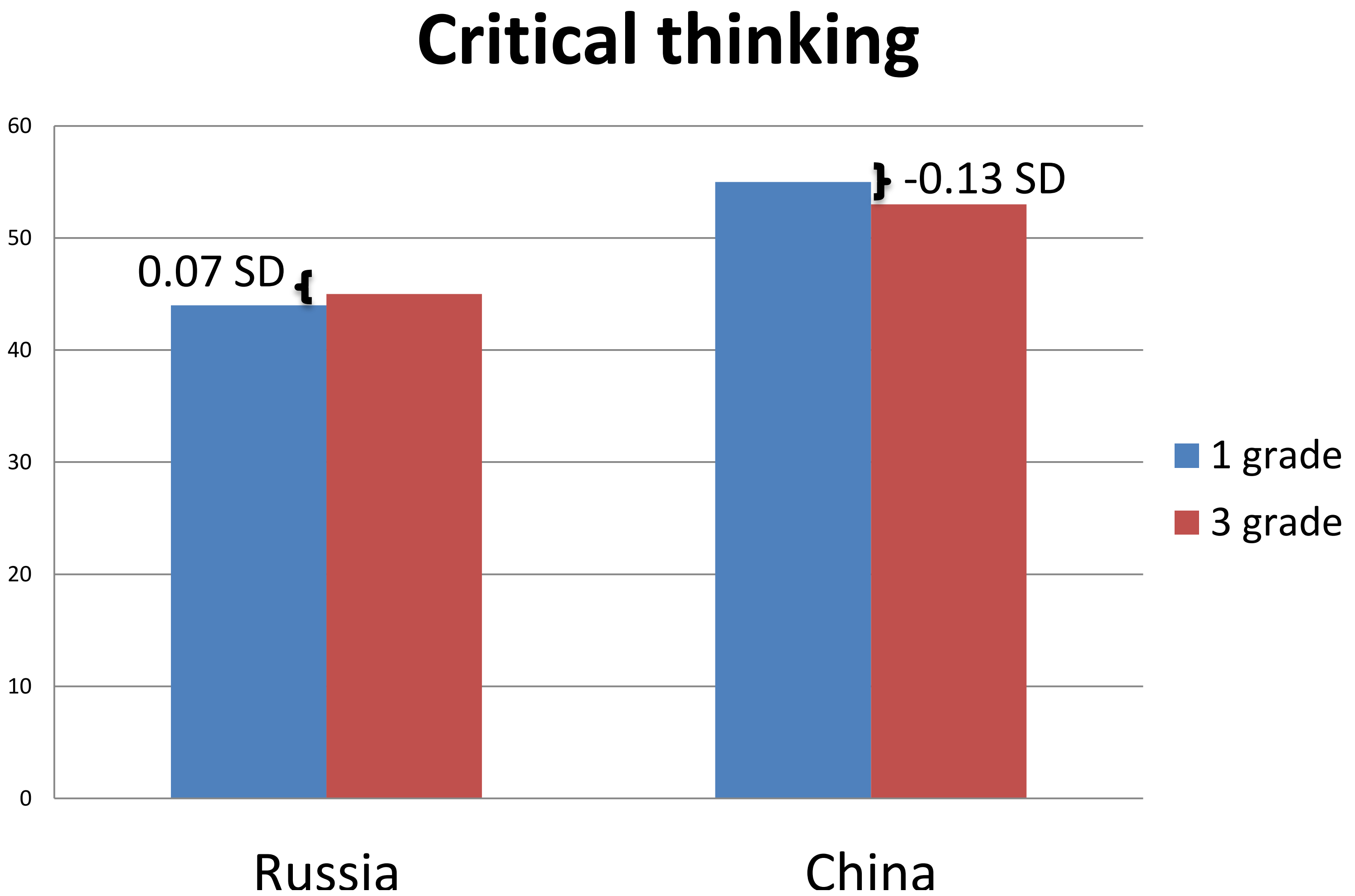


Critical Thinking Skills – Baseline Results

BASELINE – critical thinking
Comparison across countries (grade 1 & 3)



Gains?



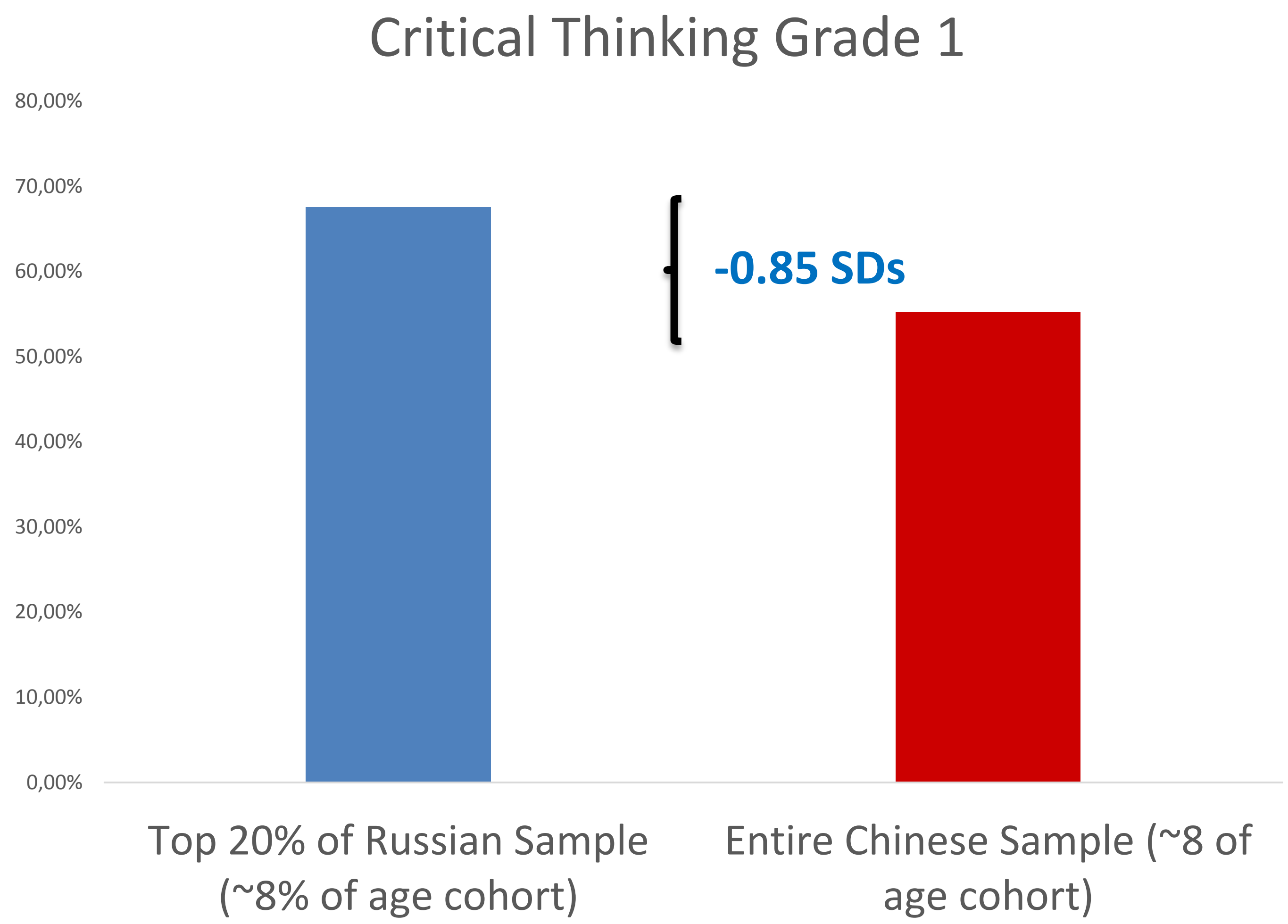
Critical thinking
60
50
40
30
20
10
0
0.07 SD
-0.13 SD
Russia
China
1 grade
3 grade

Levels of critical thinking skills ACROSS countries

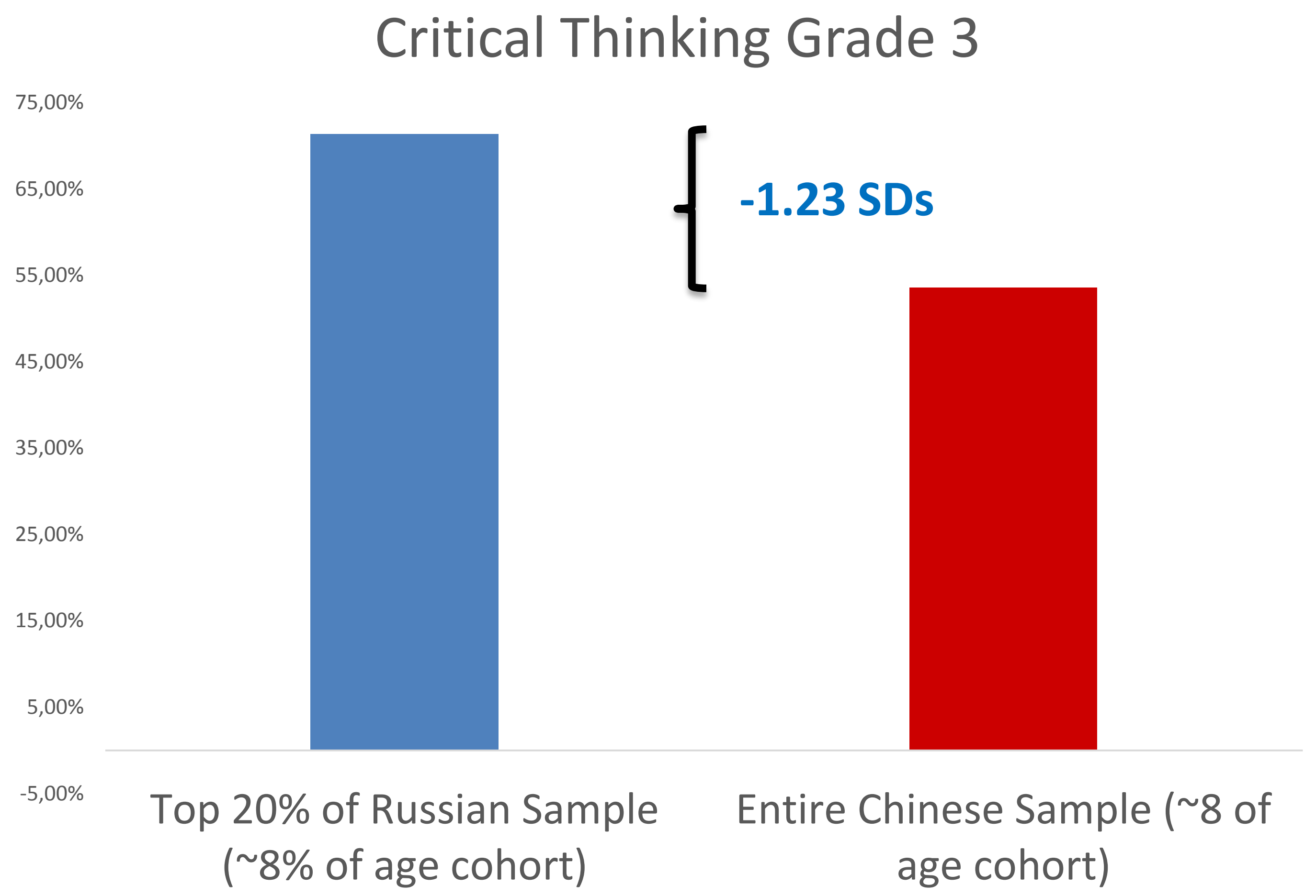
- Freshman and juniors from China (who are among the top 8% of their age cohort) significantly outperform freshman from Russia (who are in the top 40% of their age cohort) and the US

- **HOWEVER**, while Russian and US students make some gains in critical thinking, Chinese students again make negative gains

Top 8%s


Critical Thinking Grade 1
80,00%
70,00%
60,00%
50,00%
40,00%
30,00%
20,00%
10,00%
0,00%
-0.85 SDs
Top 20% of Russian Sample (~8% of age cohort)
Entire Chinese Sample (~8 of age cohort)

Top 8%s:
By grade 3, the gap is even larger

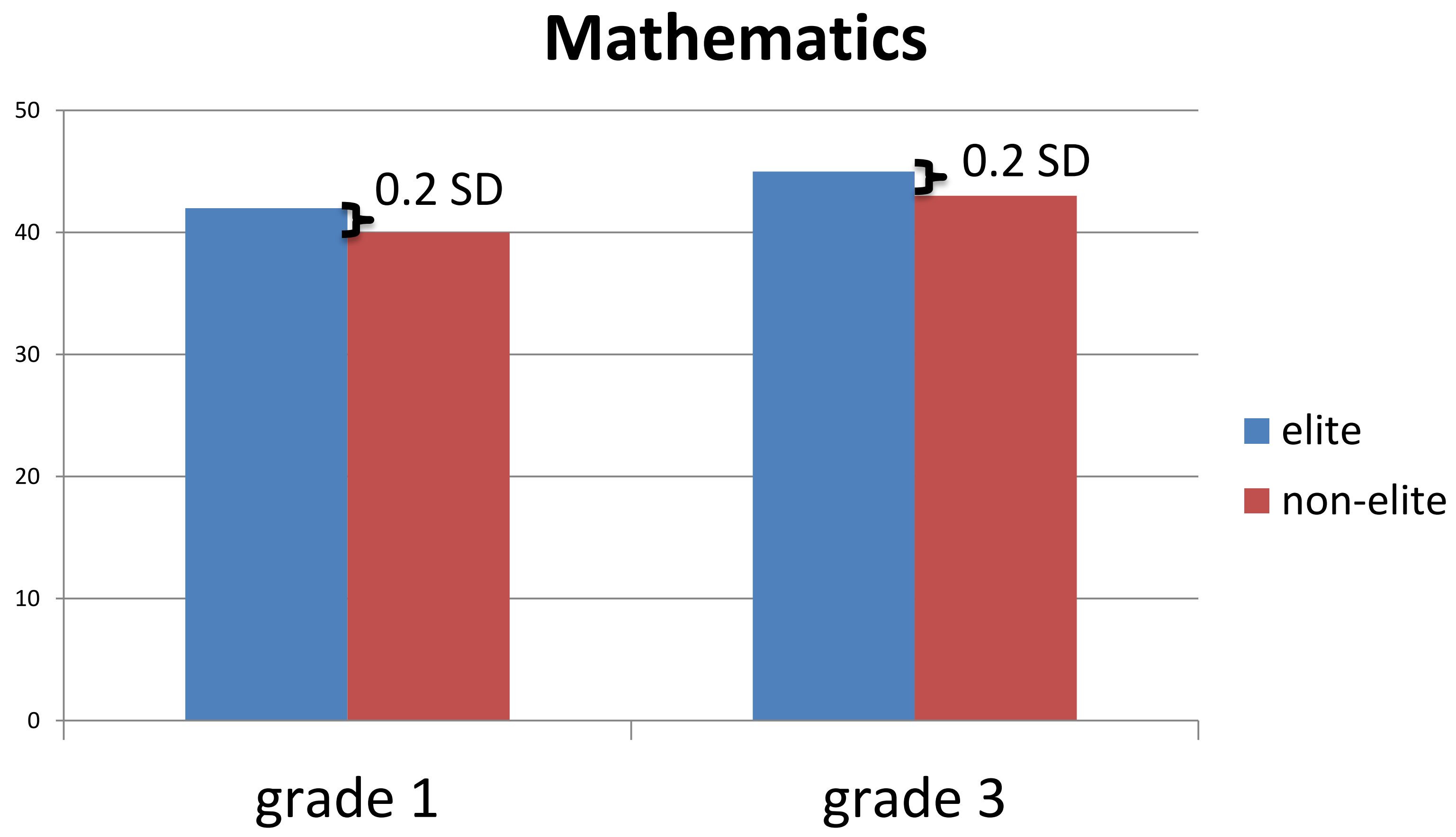


The above analysis was across countries…

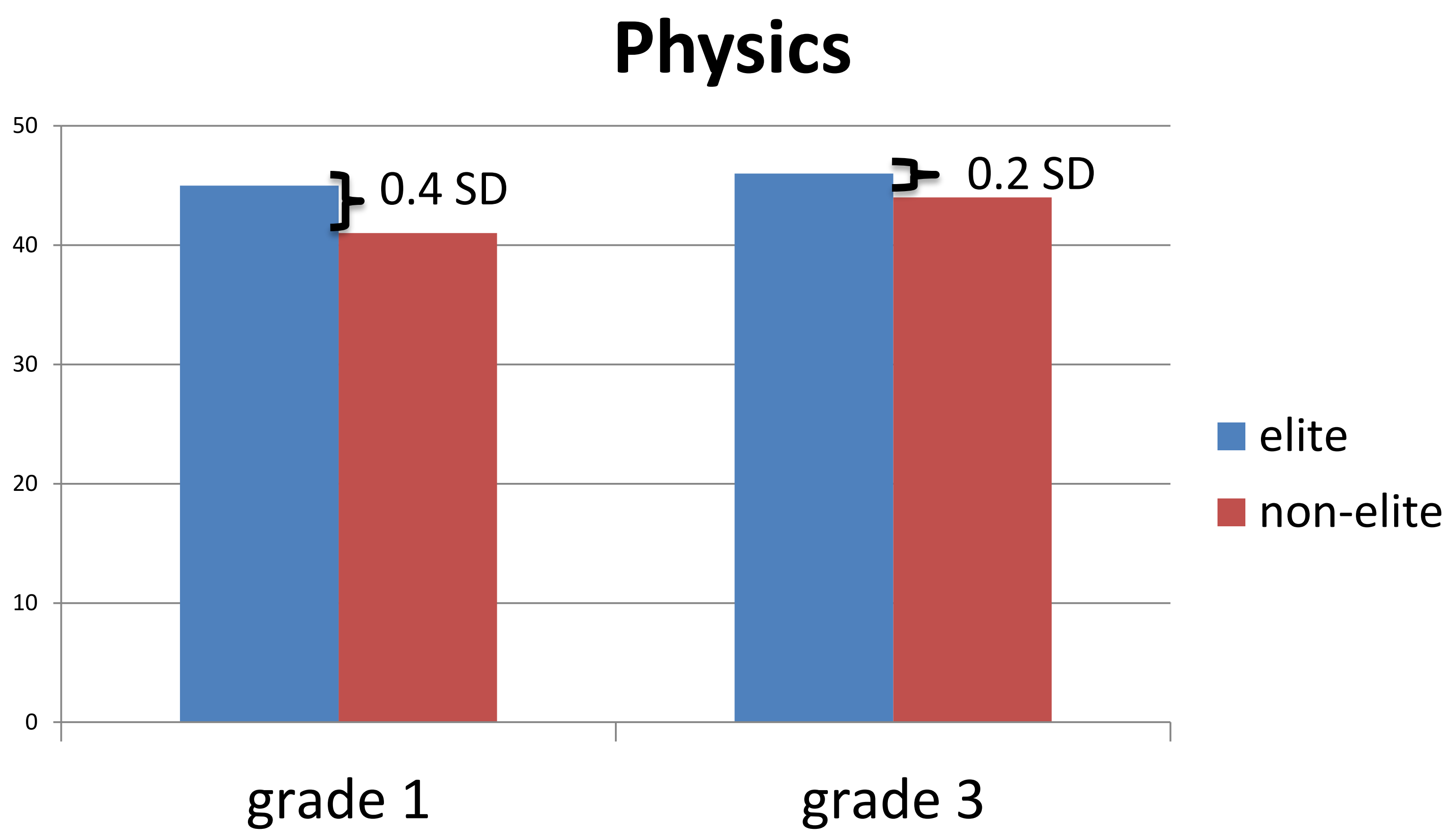
We also look at what is happening INSIDE countries…

How do students compare at different types of universities (elite and non-elite)?

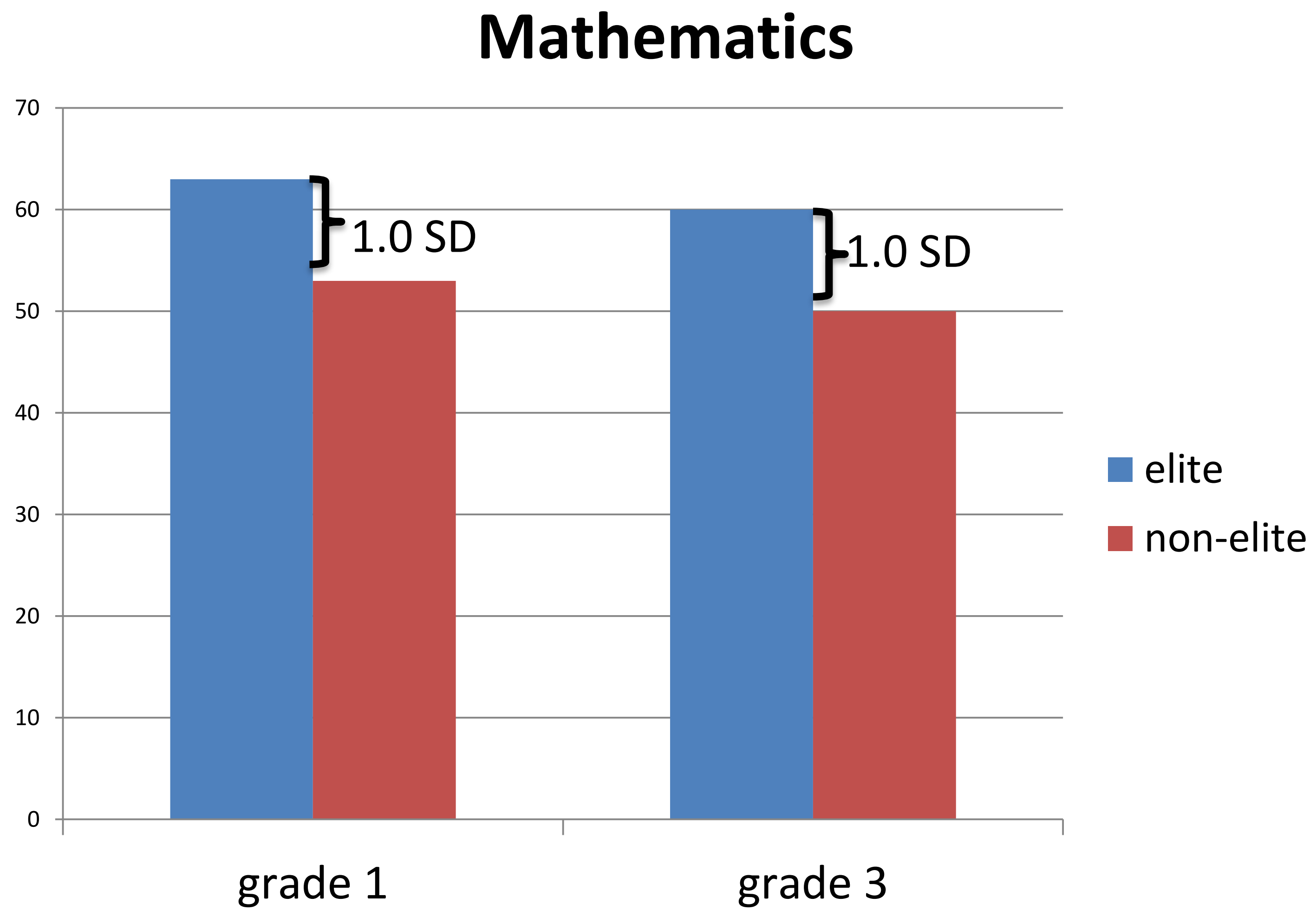
Elite vs. Non-elite: Russia



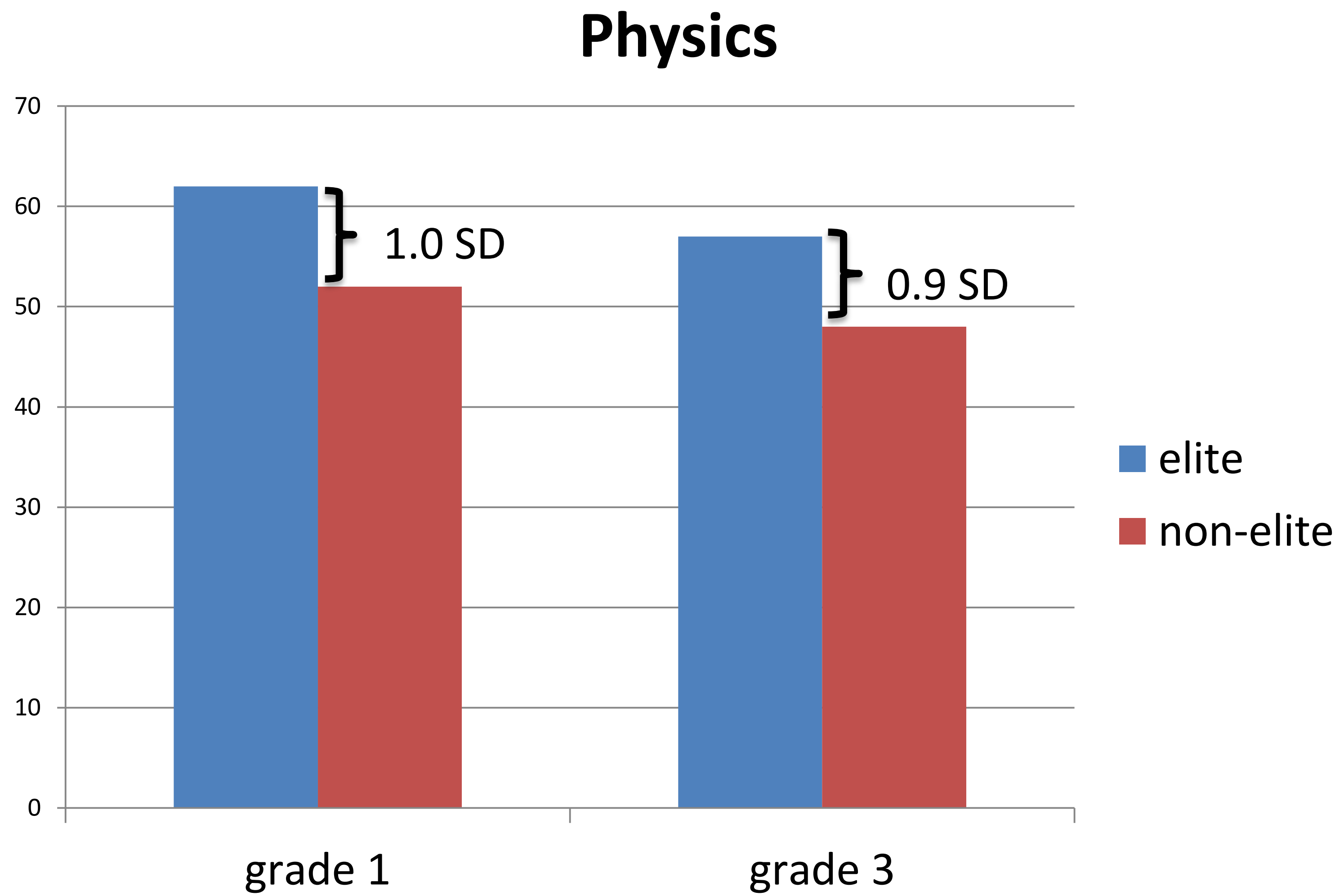
Elite vs. Non-elite: Russia



Elite vs. Non-elite: China



Elite vs. Non-elite: China



- Students in elite universities have higher levels of academic skills than students in non-elite universities
- But this is much more true for China than Russia (this is because of SORTING into universities as attested by grade 1 student differences)
- Students in elite universities make comparable gains compared to students in non-elite universities (implications?)

Finally, one example of looking at differences across students:

Gender

Russia: female students make significantly **less** gains in physics (.26 SDs) compared to male students

	(1) MATH	(2) PHYSICS
Female	0.0010	0.0029
	(0.044)	(0.065)
Grade 3	0.3014***	0.4534***
	(0.032)	(0.043)
Female X Grade 3	-0.0378	-0.2566***
	(0.064)	(0.093)

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

China: female students make **greater** gains in math (.20 SDs) and physics (.16 SDs) relative to male students

	(1) MATH	(2) PHYSICS
Female	-0.0646*	-0.2560***
	(0.037)	(0.040)
Grade 3	-0.1883***	-0.1516***
	(0.031)	(0.034)
Female * Grade 3	0.2022***	0.1635***
	(0.056)	(0.061)

Standard errors in parentheses

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

- We are exploring these results further…

- How do Russia and China’s learning environments differ for different genders?

Factors influencing student learning

We collected **rich** contextual data

- Student characteristics, attitudes, and behaviors
  - Personal and educational background characteristics
  - Time use (in and out of class)
  - Study habits (in and out of class)
  - Participation in research and extracurricular activities
  - Choices/attitudes about major and studies
  - Psychological traits
  - Social networks
  - Finances
  - Expectations for the future work and study

- Instructional practices (student-reported)
  - Active versus passive instruction
  - Clarity and organization of instruction
  - Opportunities for collaborative learning
  - Student-faculty interactions
  - Course load

- Faculty characteristics
  - Personal, educational, and work background
  - Time allocation
  - Motivations to teach and conduct research
  - Autonomy in preparing courses
  - Views on student preparedness and learning
  - Research productivity
  - Professional exposure outside the university

- Administrative procedures:
  - Procedures for organizing students into classes
  - Procedures for hiring and promoting faculty
  - Procedures for choosing and revising curricula
  - Regulations/incentives on teaching and research
  - Skill evaluation of incoming and graduate students
  - Attitudes towards and use of assessment tools

What kind of questions can we answer with this data?

- E.g. how much do instructional styles (e.g. active versus passive) matter for learning?

- E.g. how do professor behaviors like time spent on different activities relate to student learning?

- E.g. what peer behaviors influence student learning and social-emotional well-being?

What kind of questions can we answer with this data?

An example from China

What is the impact of faculty behavior on student learning in universities?

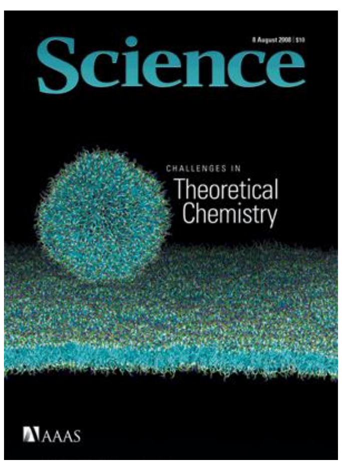
One important question:

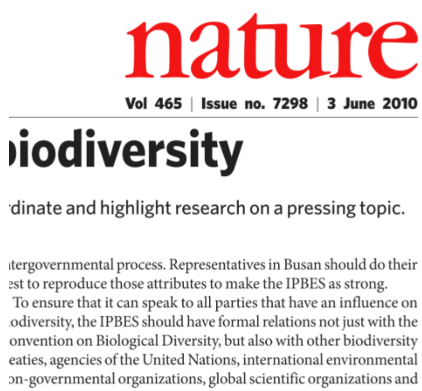
If a professor spends more time on research, does this help or hurt student learning?

- On the one hand, it **helps** because research strengthens teaching
- On the other hand, it **hurts** because research takes time away from teaching

This is a topic of great interest … with no good answer

- Over 60 studies tried to tie faculty research to student learning
- Analyses from ALL studies are CORRELATIONAL—no one has looked at the CAUSAL relationship
- Only one study looks at impacts on achievement
- In fact, this gap in the literature is so stark that multiple editorials have been published in *Science* and *Nature* pointing to the need for better data to answer this question




nature
Vol 465 | Issue no. 7298 | 3 June 2010

iodiversity

dinate and highlight research on a pressing topic.

ntergovernmental process. Representatives in Busan should do their est to reproduce those attributes to make the IPBES as strong.
To ensure that it can speak to all parties that have an influence on odiversity, the IPBES should have formal relations not just with the onvention on Biological Diversity, but also with other biodiversity eaties, agencies of the United Nations, international environmental on-governmental organizations, global scientific organizations and


EDUCATIONFORUM
SCIENCE EDUCATION
Changing the Culture of Science Education at Research Universities
W. A. Anderson,[1] U. Banerjee,[2] C. L. Drennan,[3] S. C. R. Elgin,[4] I. R. Epstein[5], J. Handelsman,[6] G. F. Hatfull,[7] R. Losick,[8]* D. K. O'Dowd,[9]* B. M. Olivera,[10] S. A. Strobel,[6] G. C. Walker,[3] I. M. Warner[11]

Professors have two primary charges: generate new knowledge and educate students. The reward systems at research universities heavily weight efforts of many professors toward research at the expense of teaching, particularly in disciplines supported extensively by extramural funding (1). Although education and lifelong learning skills are of utmost importance in our rapidly changing, technologically dependent world (2), teaching responsibilities in many STEM (science, technology, engineering, and math) disciplines have long had the

Ours is the first study with a good estimation strategy that can assess a causal impact.

How did we achieve this?

We conducted a “quasi” experiment using the pilot data from China

[*We are going to do this and much more for both China and Russia using the baseline data – stay tuned*…]

We compare the learning outcomes of "twins"

One twin with professors that **DID** spend a lot of time on research

Another twin with professors that did **NOT** spend a lot of time on research

In fact, we took the analysis one step further…

We also observed learning differences for the **same** student across these two situations (controlling for outside factors):

Situation A: DID have professors who spent a lot of time on research

Situation B: did NOT have professors who spent a lot of time on research

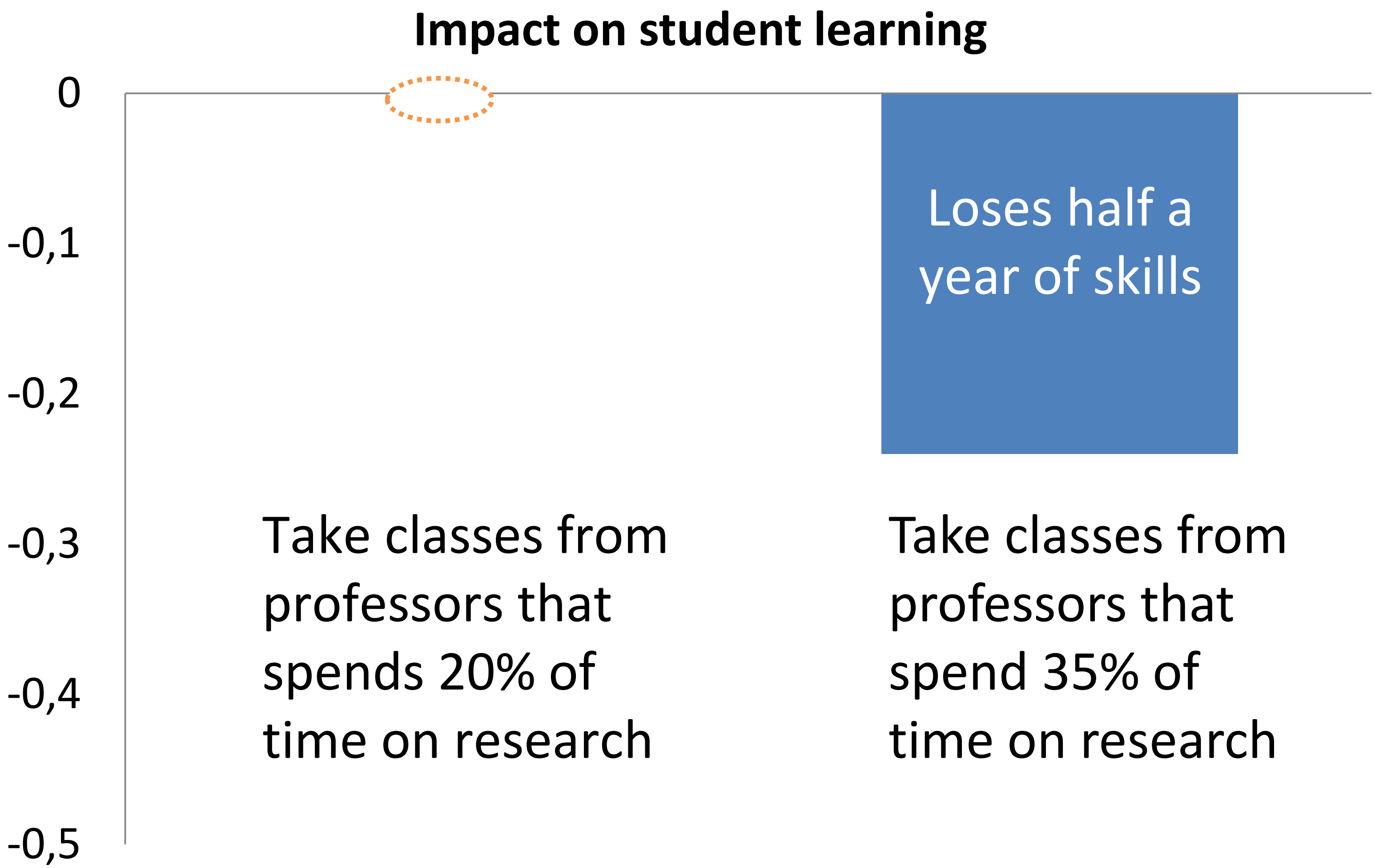
How do we measure professor research commitment?

Two measures of faculty research commitment:

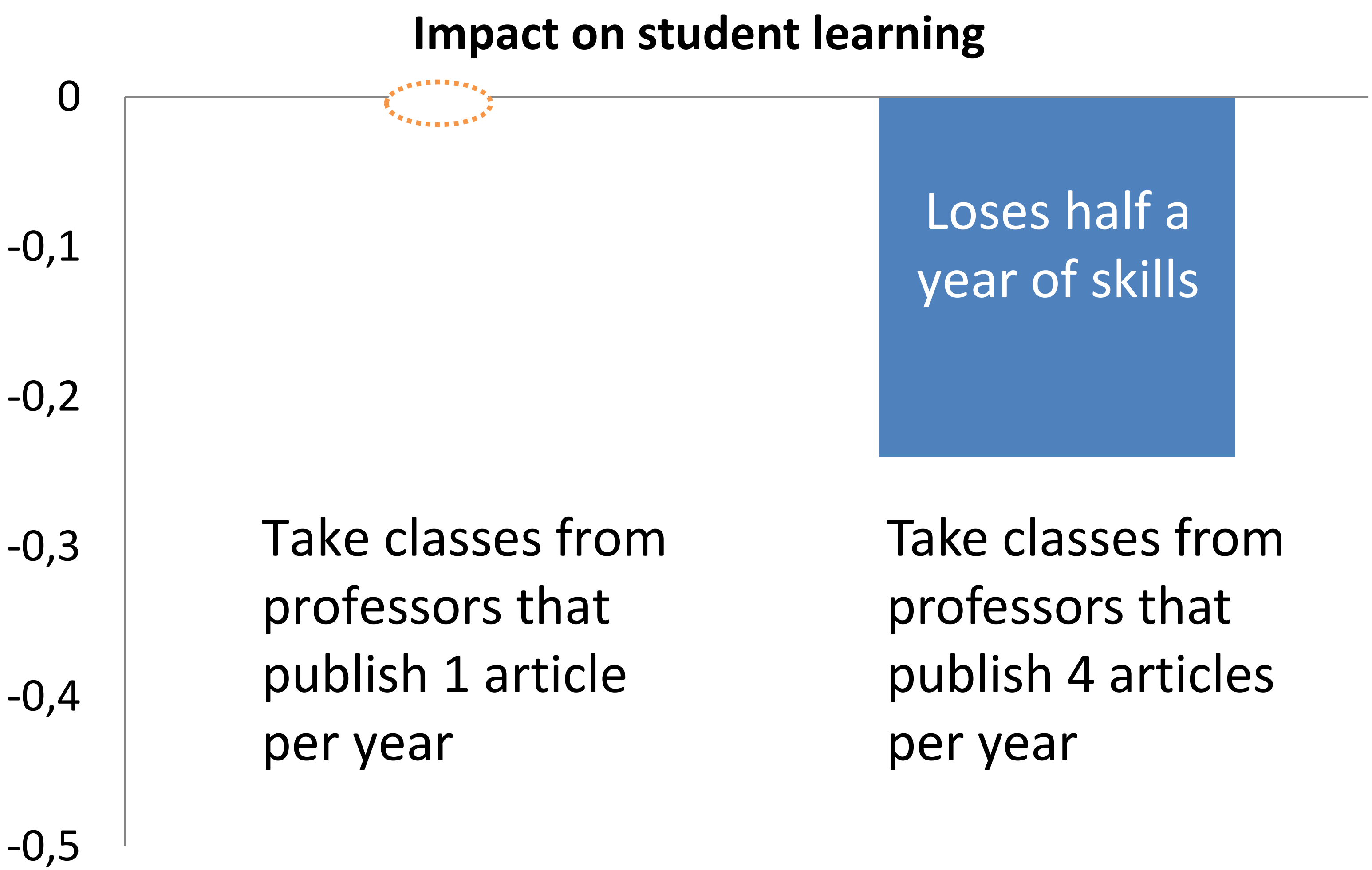
- Research time- The proportion of time the professor devotes to research out of all working hours

- Publication intensity-The number of academic publications (books, journal articles etc.) the professor publishes per year

RESEARCH TIME



PUBLICATION INTENSITY



In Sum,

Our study found that professor research time has a negative impact on student learning in China

Implications for reforming faculty incentives between teaching and research in Chinese universities?

Next steps?

For the first set of participating countries

- Analyze & report data from the Baseline
- Conduct the 1st follow-up assessment/survey
  - Academic skills (+ major-specific like CS and EE)
  - Higher order skills (ability to learn and make good choices)
  - Collect LOTs of information about curricula
  - Apply a different set of survey questionnaires to gather more contextual data
- Conduct a 2nd follow-up survey of graduates

Conduct the study in India as well as other countries (Japan, Korea, Brazil, Germany, and others). This will provide more context for how to interpret the results of the study.

Thank you!