Gender Differences in Top-Performing Math Students' Achievement and Motivation: An IPD Meta-Analysis

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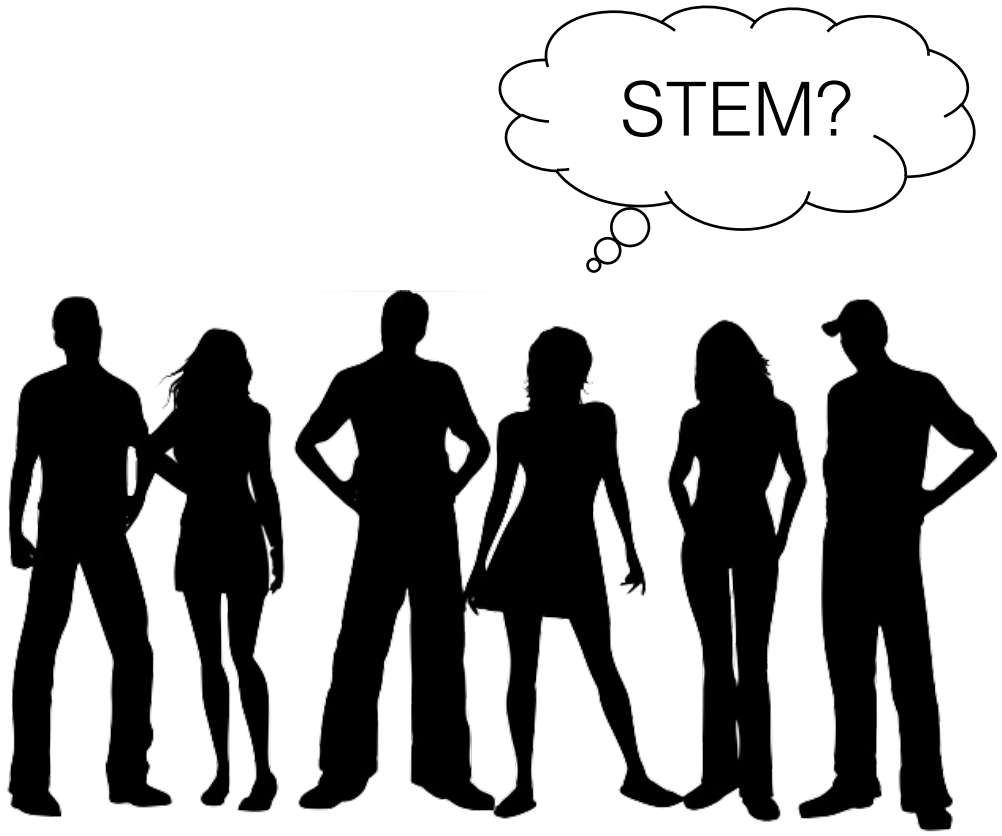

Halpern et al., 2007; Park et al., 2007
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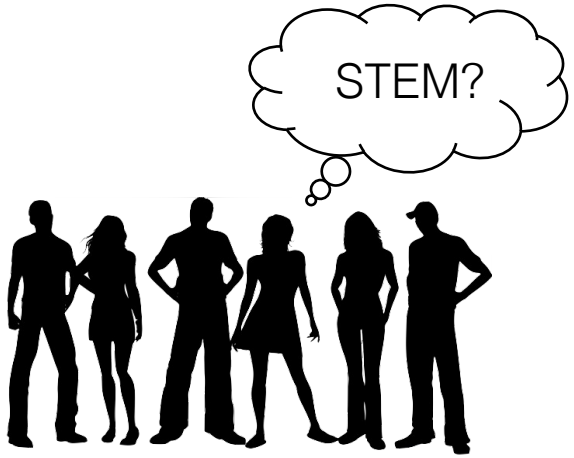
Simplified Situated Expectancy–Value Theory



achievement

achievement motivation

Ceci et al., 2014; Eccles & Wigfield, 2020
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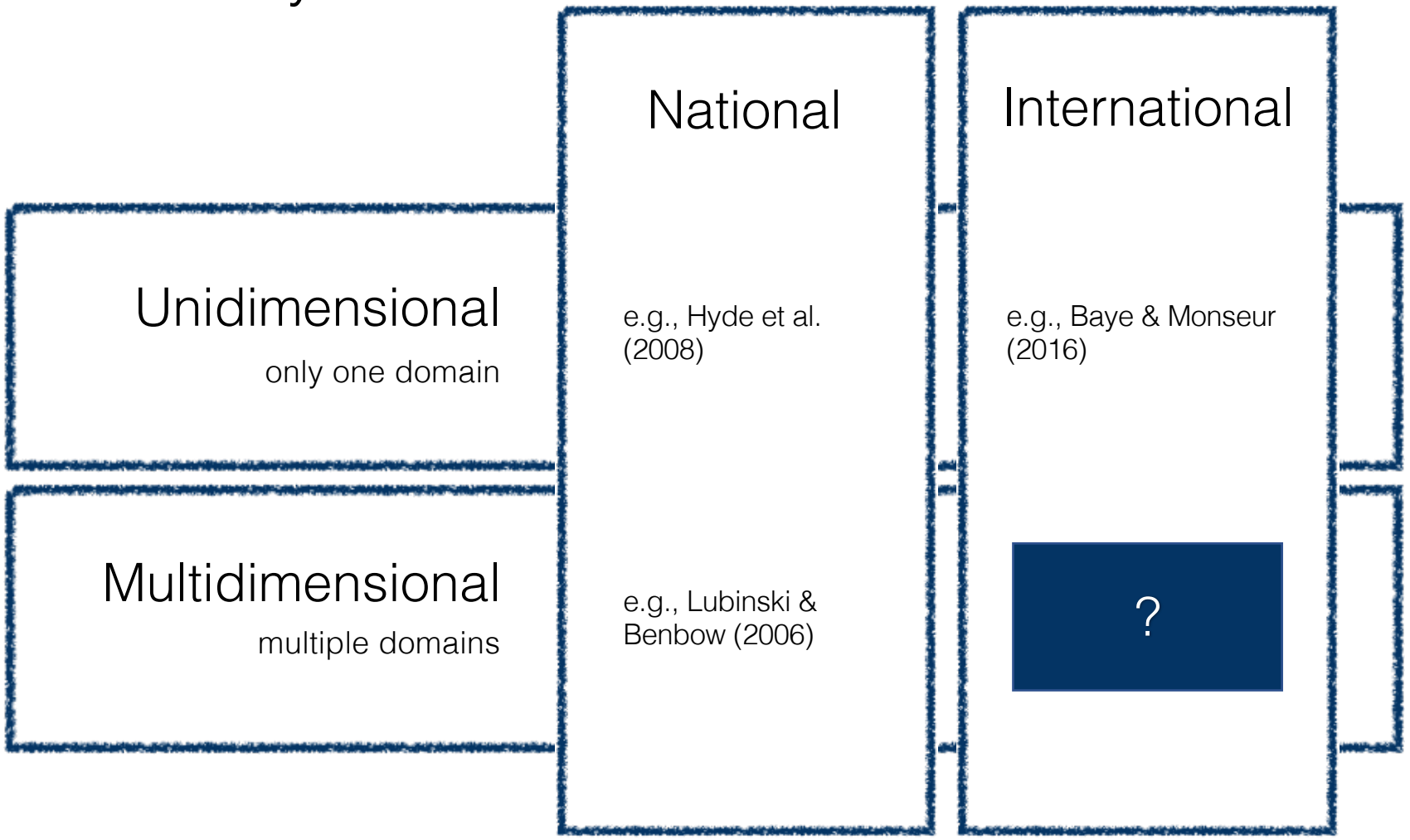
Previous meta-analyses



Research questions

1. How large are gender differences in achievement, achievement profiles, and achievement motivation in mathematics, reading, and science in the group of top-performing math students across countries?

2. To what extent do sociocultural factors (i.e., the level of gender equality in a country) moderate gender differences in the group of top-performing math students?

    a. Gender differences decrease with increasing levels of gender equality.

    b. The share of female students in the top 5% in mathematics increases with increasing levels of gender equality.

Eccles & Wigfield, 2020; Wood & Eagly, 2012

Method

image credit: Jesswin Thomas, unsplash

Individual Participant Data (IPD) meta-analysis

International large-scale assessment data

- ✓ Representative
- ✓ Unselective samples of top-performing math students
- ✓ Well-defined populations

\+

Meta-analytic techniques

= “Gold standard” when studying gender differences

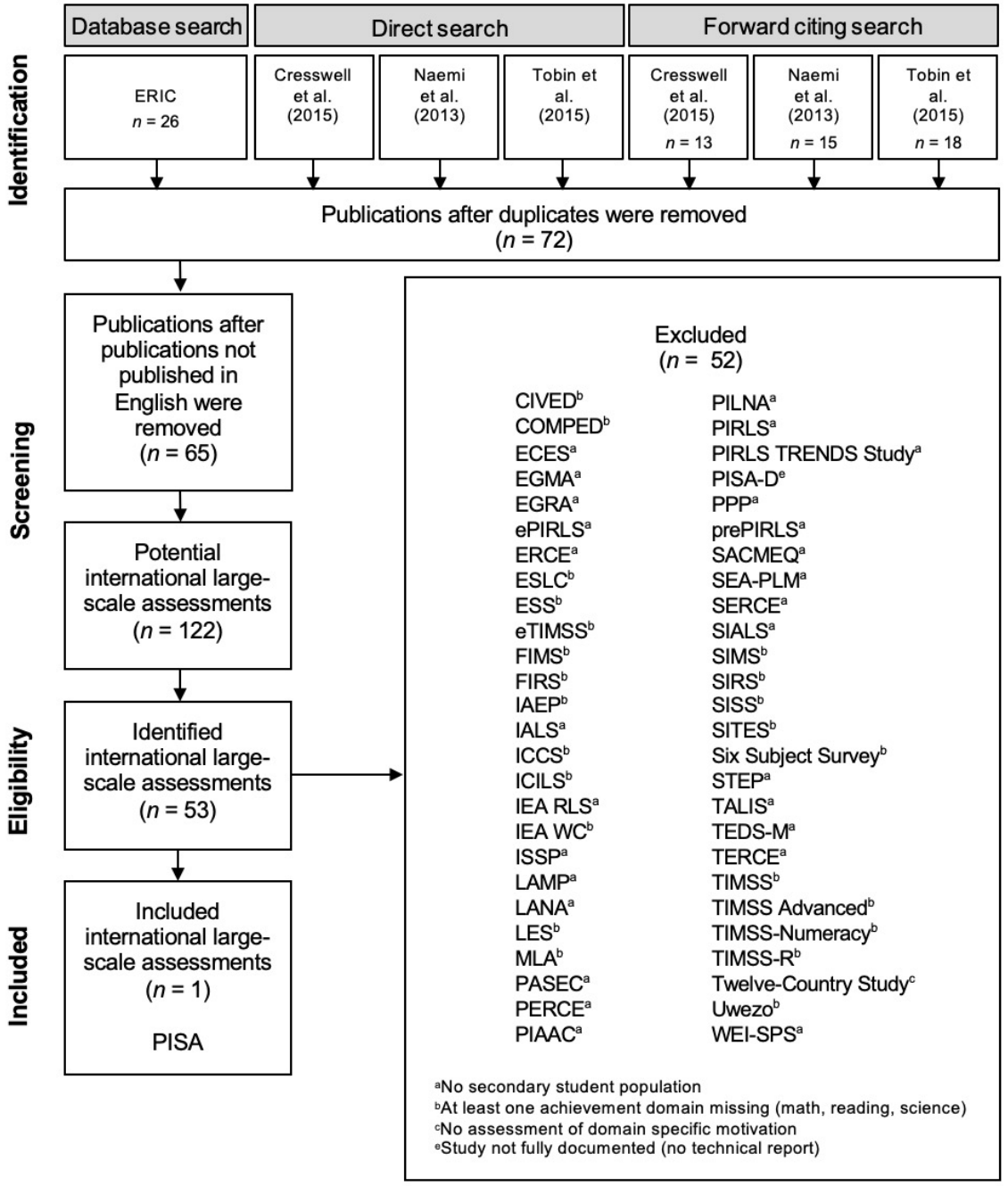
Hedges & Nowell, 1995; Reilly et al., 2019; Shrout, 2009
image credit: Tomas Knop, www.freepic.com

Search criteria for international large-scale assessments:

- Secondary student population
- Achievement domains: math, reading, science
- Assessment of domain-specific motivation
- Fully documented (July 2019)

Identified international LSAs: 53

Included LSAs: 1 (PISA)



Sample

- 6 PISA cycles (2000–2015)
- Up to 343 representative student samples
- Top 5% in mathematics in their respective countries
- *N* = 113,864, 15-year-olds
- 82 countries

Measures

Standardized achievement tests in mathematics, reading, and science

26 motivation self-report scales related to mathematics, reading, and science

Students' gender: self-categorization (boy/girl)

Achievement profiles: Difference between an individual student's achievement score in two domains

- –Math–Reading
- –Science–Reading
- –Math–Science

Meta-analytic procedure

(1) Country-specific, weighted effect sizes: Cohen‘s *d* (Cohen, 1988)

$$d = \frac{M_m - M_f}{SD_{OECD}}$$

(2) Multilevel random effects models to account for the dependencies between the effect sizes

- R package “metaSEM” (Cheung, 2015)

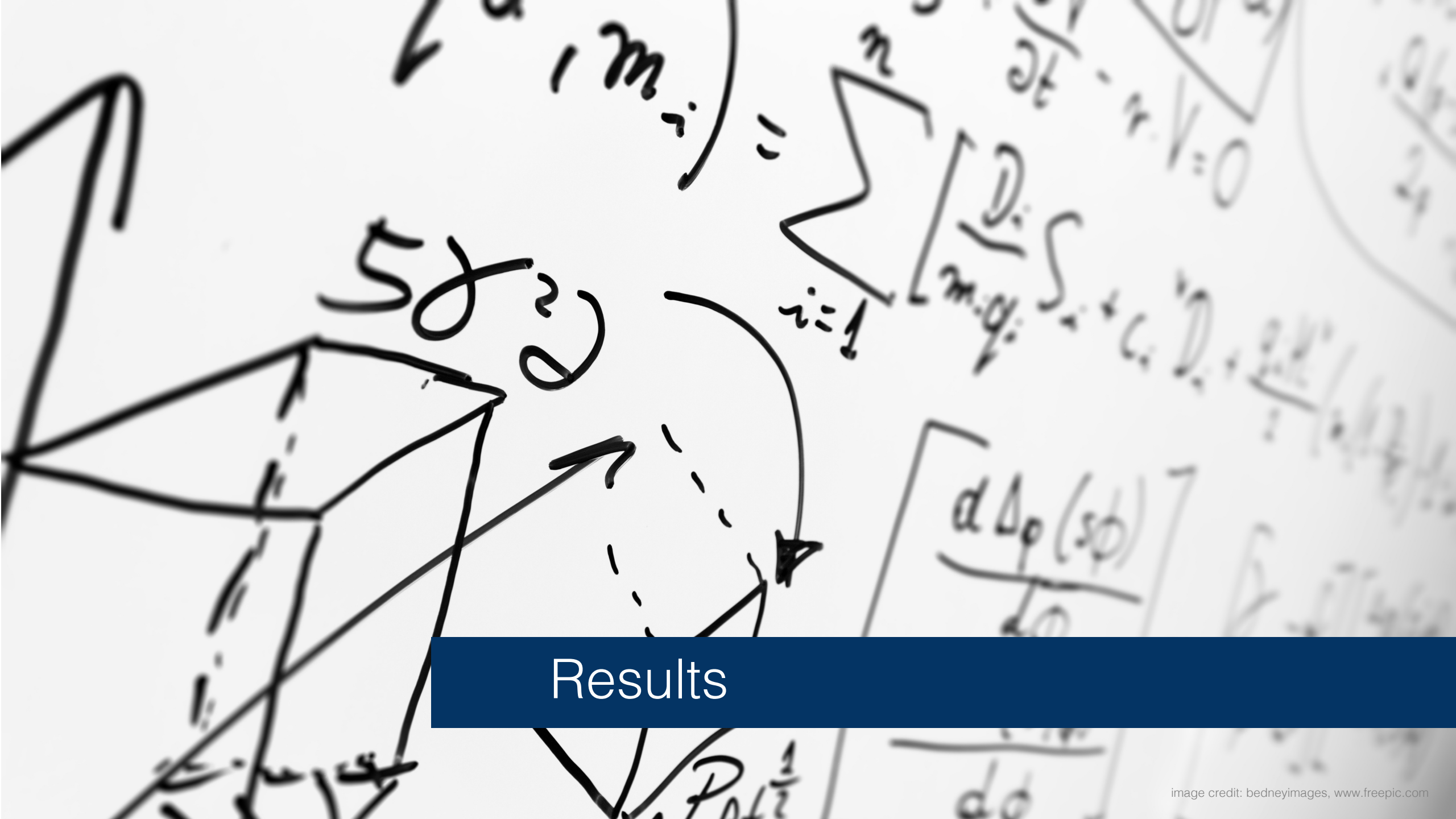
(3) Moderator analyses: Multivariate meta-regression models

Moderators

Gender equality indicators (2000–2015, imputed)

- Female-to-male enrollment ratio in primary, secondary, and tertiary education
- Women's share of research positions
- Women's share of higher positions (employment in senior and middle management, i.e., legislators, senior officials, managers)

Else-Quest & Grabe, 2012



Results

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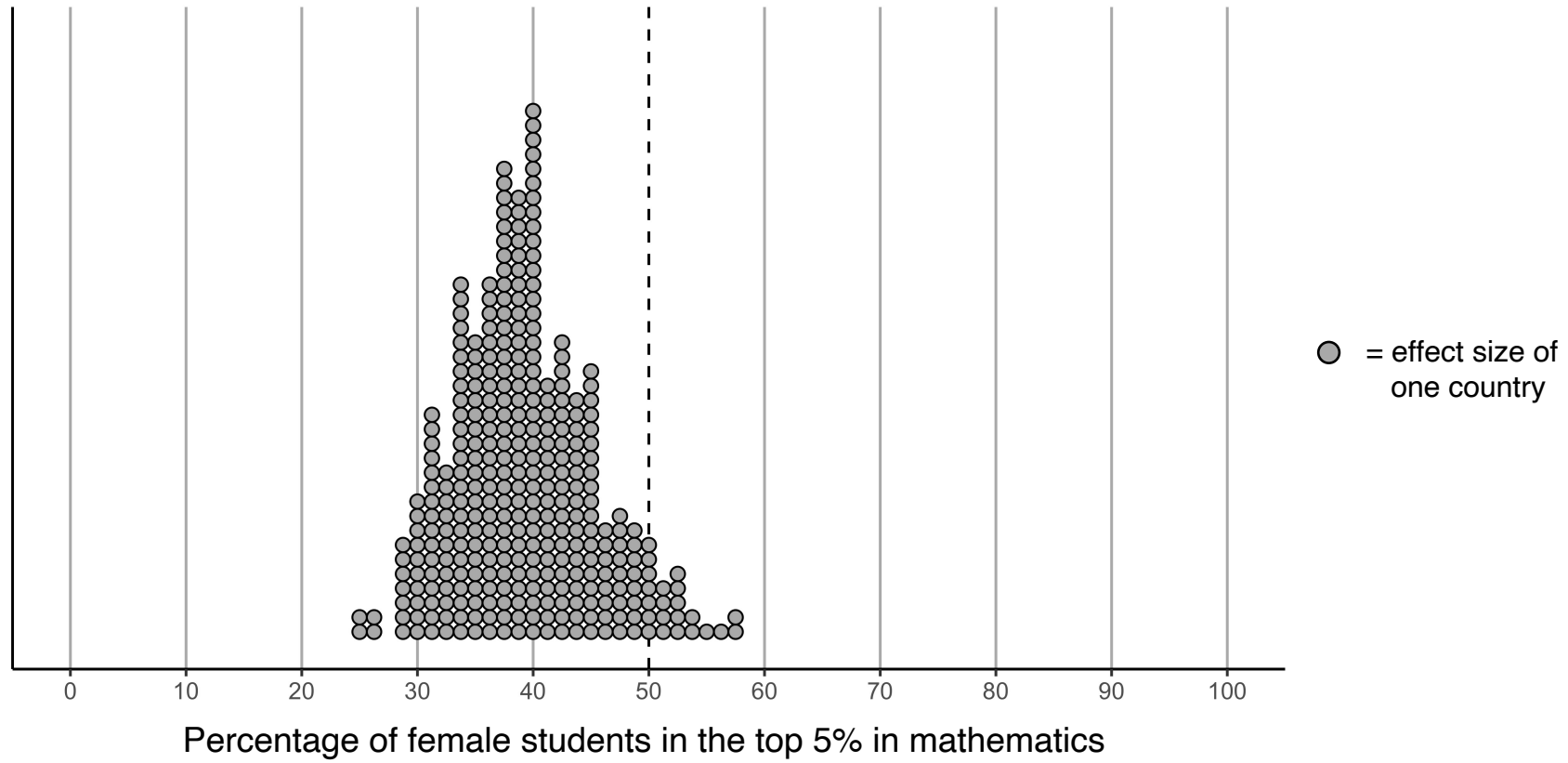
Gender distribution



Gender differences

moderate $0.35 < \|d\| \leq 0.65$	small $0.10 < \|d\| \leq 0.35$	negligible $0.00 \leq \|d\| \leq 0.10$
Verbal self-concept	Reading achievement	Instrumental motivation in science
Interest in reading	Math anxiety	Interest in astronomy
Enjoyment of reading	Attributions to failure in mathematics	Math achievement
Interest in human biology	Work ethic in mathematics	Science achievement
Interest in motion and forces	Interest in the biosphere	Subjective norms in mathematics
Interest in physics	Interest in plant biology	Interest in mathematics
Interest in energy transformation	Interest in diseases	Science self-efficacy
	Math self-efficacy	Future-oriented science motivation
	Math intentions	Enjoyment of science
	Instrumental motivation in mathematics	Personal value of science
	Math self-concept	Interest in chemistry
	Science self-concept	Interest in geology
	General value of science	
	Interest in the history of the universe	

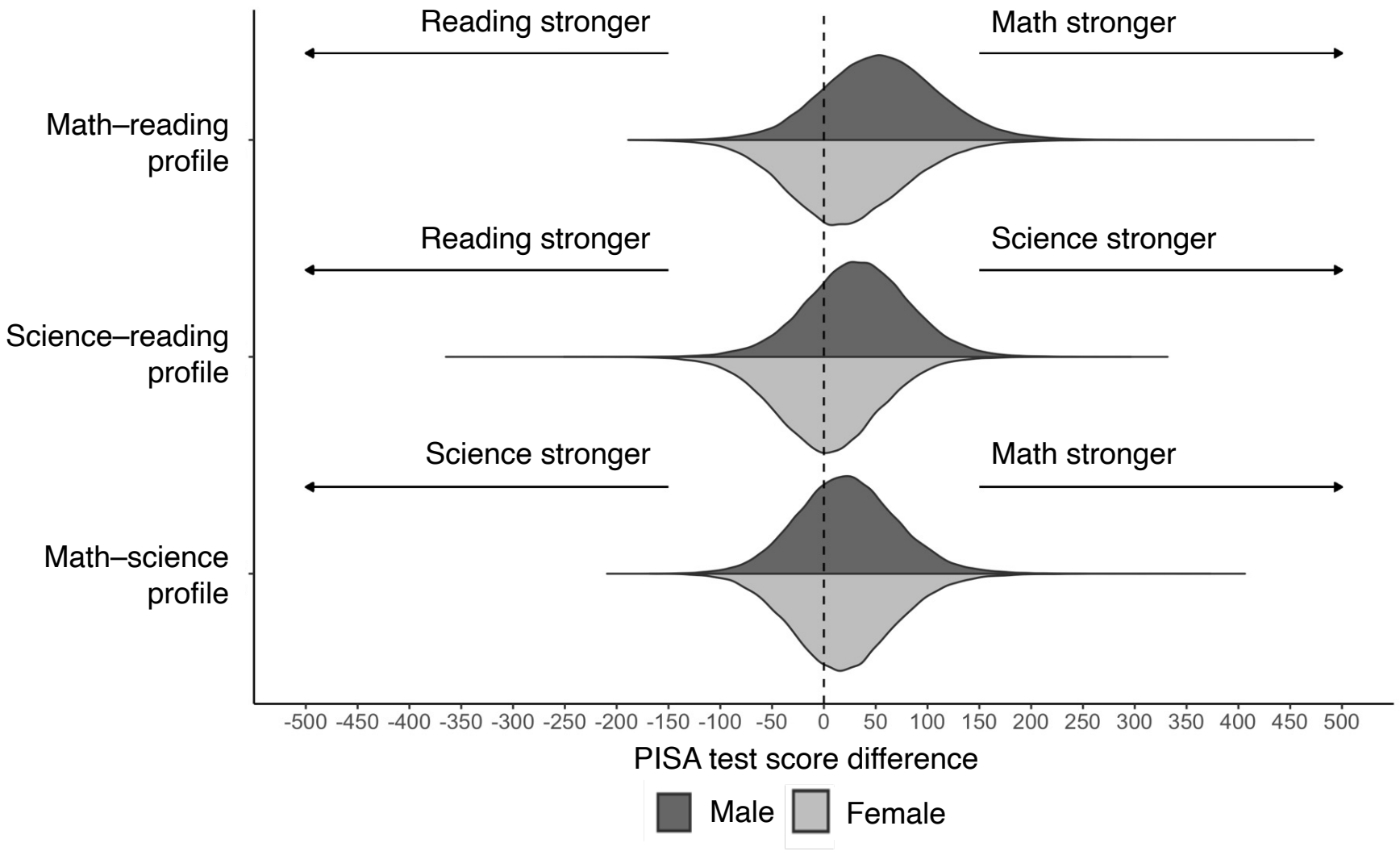
Female advantage

Male advantage

$d = 0$

Hyde, 2005

Achievement profiles



Moderator analyses

Table 1

Moderating Effects of Gender Equality Indicators

	Women's share of…		Female-to-male enrollment ratio in…		
	higher positions	research positions	primary education	secondary education	tertiary education
% female students in the top 5% in math					✓
Math–reading profile score (females)					✓
Math–reading profile score (males)					✓
Science–reading profile score (females)					✓
Math–science profile score (females)	✓				

Discussion

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Female and male students in the top 5% in mathematics were **similar** in their achievement in mathematics, reading, and science and in 23 out of 30 motivational characteristics

→ Supports gender similarities hypothesis (Hyde, 2005)

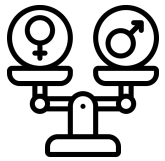


image credit: Freepic; flaticon.com

Male students

– more interested in physics- and engineering-related topics

– math-oriented achievement profile

Female students

– only two out of five students were female

– more interested in biology and health-related topics

– more motivated in the verbal domain

– more balanced achievement profile

image credit: Freepic; flaticon.com

Associations with gender equality

- **positive relation** with share of female students in the top 5% in mathematics
- achievement profiles were **more balanced** with increasing levels of gender equality

→ (Partly) supports Social Role Theory and Situated Expectancy–Value Theory

Eccles & Wigfield, 2020; Wood & Eagly, 2012

Limitations

Data were not available for all countries around the world

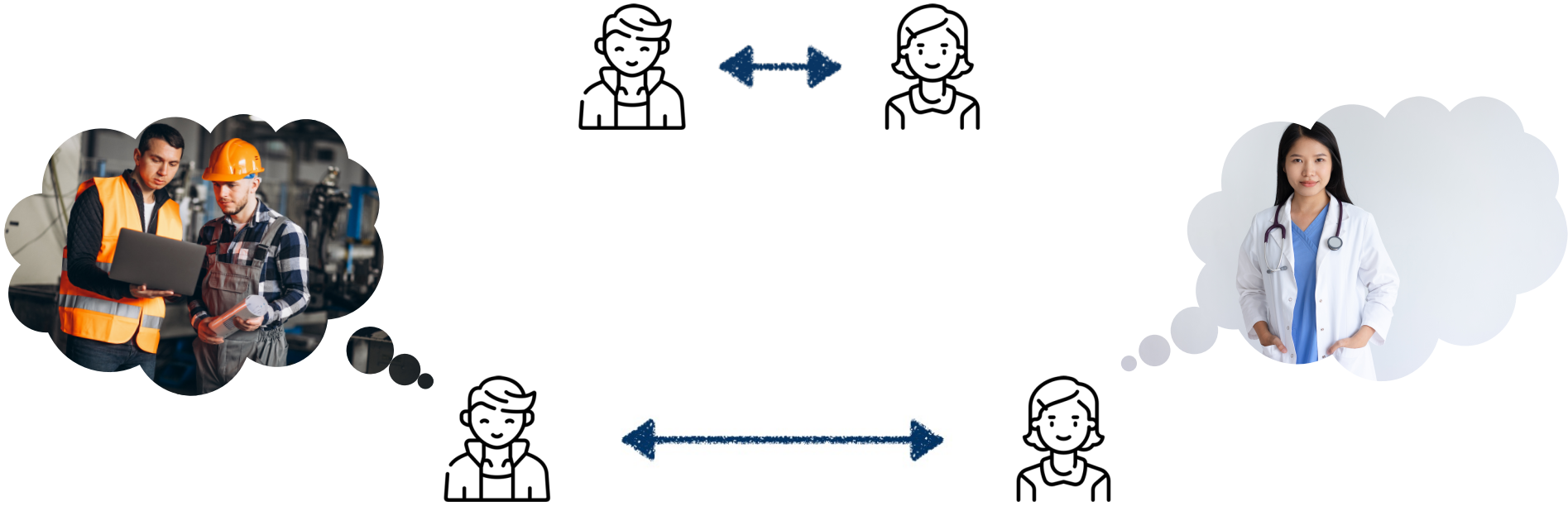
– A more diverse sample of countries would be desirable to draw even more generalizable conclusions

Definition of “top-performing math students” as the top 5% in mathematics

– At least some of the students in the lowest-achieving countries are not top-performing math students in an absolute sense (in terms of the PISA Proficiency Level)

\+ Better balance in how country-specific results are weighted (more balanced sample sizes in high- and low-achieving countries, use of PISA 2000 cycle)

Conclusion



Differences might contribute to women’s underrepresentation in STEM

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In press at the Journal of Educational Psychology!

Keller, L., Preckel, F., Eccles, J. S., & Brunner, M. (in press). Top-performing math students in 82 countries: An integrative data analysis of gender differences in achievement, achievement profiles, and achievement motivation. Journal of Educational Psychology.

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Thank you!

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