

The Female Fish in the Big Male Pond:

Gender and Achievement Compositions’ Impact on Mathematics Self-Efficacy and STEM Career Aspirations

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Theoretical Background

- Girls report lower STEM career aspirations than boys (OECD, 2017)
- Mathematics self-efficacy predicts STEM career aspirations (Mau & Li, 2018); girls report lower self-efficacy than boys (e.g., Else-Quest et al., 2010)
- Competence beliefs are not only shaped by individual factors (e.g., achievement), but also by **school composition**:

Achievement Composition

- Big-Fish-Little-Pond Effect (BFLPE; Marsh & Parker, 1984)
- Higher achieving peers → lower self-concept
- Achievement composition influences aspirations
 - both directly (Marsh & O'Mara, 2010)
 - and indirectly via self-concept (von Keyserlingk et al., 2020)
- Evidence primarily based on academic self-concept, with limited evidence for self-efficacy

Gender Composition

- Female students benefit from same-gender peer environments, due to greater access to female role models, more teacher attention (e.g., Bassi et al., 2018; Kessels & Hannover, 2008; Mau & Li, 2018)
- No effects on male self-concept (Kessels & Hannover, 2008)

Research Gap:

- Limited evidence on self-efficacy (vs. self-concept) as mediator
- Lack of integrated models combining both composition effects
- Cross-national variation remains inconclusive (Guo et al., 2024)

Hypotheses

H1: Higher school-average achievement is associated with lower STEM career aspirations, partially mediated by mathematics self-efficacy

H2a: A higher proportion of boys is associated with lower female mathematics self-efficacy and STEM career aspirations

H2b: The proportion of boys is not associated with male mathematics self-efficacy or STEM career aspirations

Methods

Data & Sample

- Data from PISA 2022 (OECD, 2023)
- $N = 571,415$ students from 18,292 schools in 75 countries
- $M_{age} = 15.79$; 49.89% female
- Exclusions: Schools with <10 students and countries without Global Gender Gap Index data (GGI; World Economic Forum, 2022)

Measures

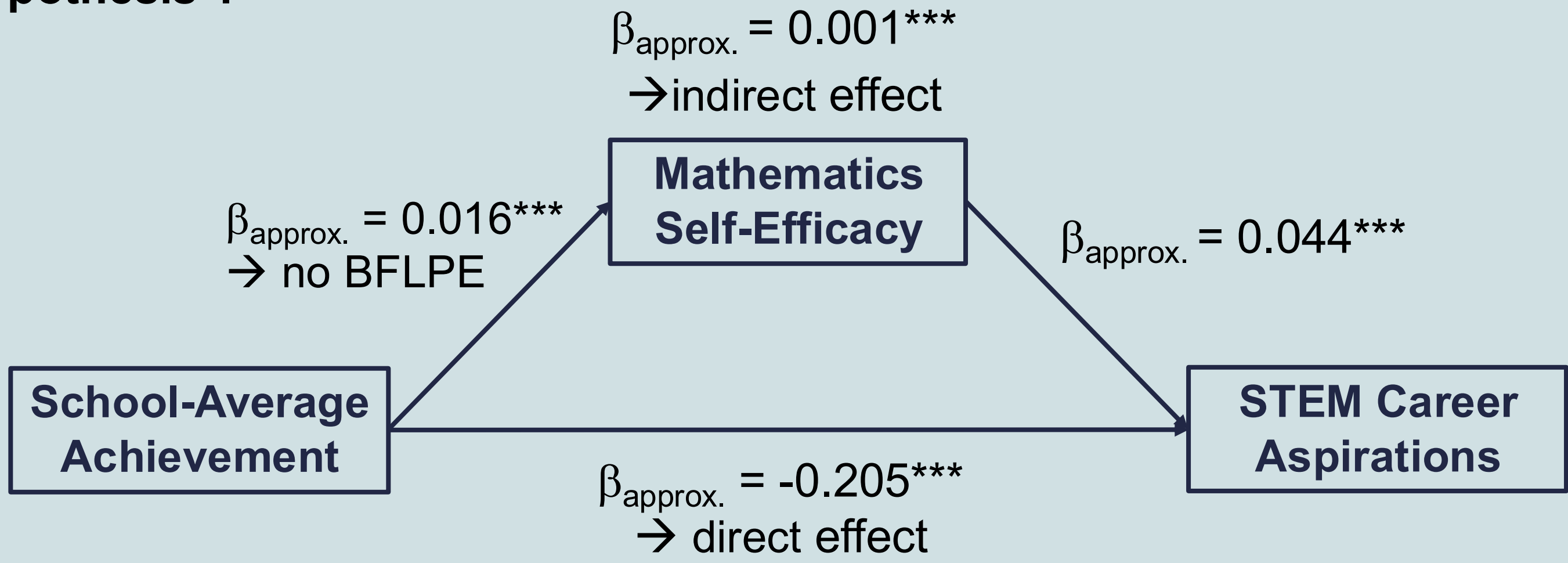
- Mathematics achievement:**
 - 10 plausible values per student
 - School-average achievement aggregated at school level
- Gender:**
 - Student gender: self-report (male/female)
 - School-level: proportion of boys
- Mathematics self-efficacy**
 - 9 items (4-point scale: not at all confident – very confident)
 - Latent construct
- STEM career aspirations:**
 - Expected occupation at age 30
 - Coded using ISCO-08 classification
 - Dichotomous (0 = non-STEM; 1 = STEM)

Analyses

- Conducted in *Mplus* 8.5 (Muthén & Muthén, 1998-2017)
- Plausible values handled via multiple imputation
- H1:
 - Two-level mediation model with random slopes
 - Compositional effects = between-level – within-level effects
- H2:
 - Cross-level interactions (gender-specific effects)
 - Analyses conducted separately across four GGI quartile groups

Results

Hypothesis 1



- Both direct and indirect effects significant
- BUT no BFLPE found and indirect effect negligible in size
- Limited support for H1

Hypothesis 2

Association between the proportion of boys in schools and...

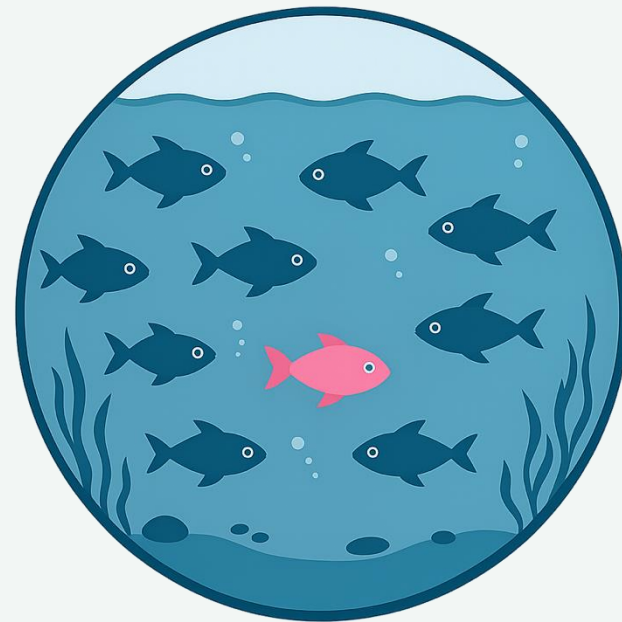
	GGI Q1 (low equality)	GGI Q2	GGI Q3	GGI Q4 (high equality)
	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
Female Self-Efficacy	-0.118***	-0.215***	-0.306***	-0.272***
Female STEM Aspirations	-0.034***	-0.014	0.025*	0.013
Male Self-Efficacy	-0.057**	0.093***	0.001	0.024
Male STEM Aspirations	0.035***	0.031**	0.053***	-0.016

- Females:* negative effect on self-efficacy, mixed effects on STEM aspirations
- Males:* mixed effects on self-efficacy, mostly positive effects on STEM aspirations; no significant effects in Q4
- H2a and H2b partially supported

Discussion

Key Findings

- No BFLPE for self-efficacy; positive effect instead → distinct mechanisms than self-concept (e.g., basking in reflected glory; Cialdini et al., 1976)
- Significant effect of self-efficacy on STEM career aspirations
- Negative direct effect on STEM career aspirations
- Indirect effect significant, but negligible in size → limited support for mediation
- A higher proportion of boys is associated with lower female self-efficacy across all country groups → consistent with literature on single-sex schooling (Kessels & Hannover, 2008)
- Effects on female aspirations are mixed → broader societal factors (e.g., gender norms, labor market conditions) may be more influential
- Effects for boys were inconsistent, with no significant effects in high gender-equality contexts (Q4)



Limitations

- Cross-sectional design → no causal inference
- School-level analysis may underestimate compositional effects (vs. class-level comparisons; Marsh et al., 2014)
- GGI quartiles: arbitrary grouping, cross-national differences only descriptive

Conclusion and Implications

- Strengthening mathematics self-efficacy is a promising lever for increasing STEM aspirations
- School environments matter:
 - both achievement and gender compositions shape students’ outcomes
- The “big, male pond” may act as a potential barrier for girls’ STEM engagement
- However, broader societal contexts shape the strength and direction of these associations



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