

Does the Mediating Role of Engagement in the Impact of Adolescents' Growth Mindset on Math Achievement Vary by Teaching Quality and Biological Sex?

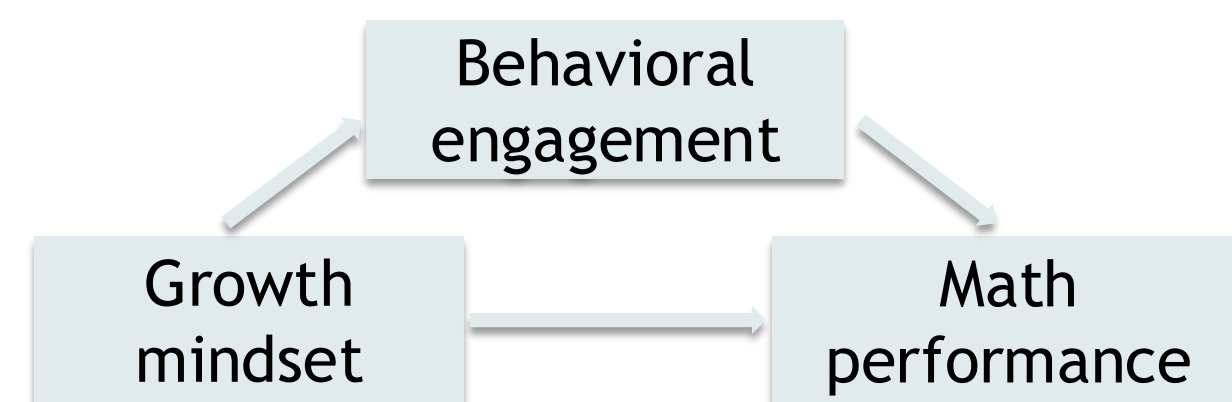
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Abstract

Our study investigated the mediating role of behavioral engagement in the growth mindset's effect on the math performance of adolescents from 15 U.S. public schools and the moderating role of teaching quality and biological sex. We found that the positive effect of a growth mindset on math achievement was primarily transmitted through math engagement. Further, the mediating role of math engagement increased with teaching quality, and a higher teaching quality was a prerequisite for a significant mediating role of math engagement. Math engagement played a more important mediating role among females than among males, although the difference was insignificant. Our study suggests that the mindset intervention does not work universally across people and contexts. A high-quality classroom environment is a prerequisite for the growth mindset to be effective.

Introduction

◆ Hypothesized Mediation Mechanisms



◆ Sample

- 1,350 students (grades 8, 10, 12) from 15 public schools

◆ Research Questions

- Does student growth mindset improve math performance through engagement?
- Does this mediation mechanism vary by teaching quality or student biological sex?

Measures

◆ **Treatment-Growth Mindset** We set high and low growth mindset levels at one standard deviation above and below the mean ($t_1 = 4.86$ vs. $t_2 = 2.81$), respectively, and focus on assessing the impact of a high vs. low growth mindset.

◆ **Moderators-Teaching Quality and Biological Sex** We set high and low teaching quality at one standard deviation above and below the mean ($w_1 = 4.69$ vs. $w_2 = 3.14$). Sex takes the value of 1 for Males and 0 for females ($w_1 = 1(Male)$ vs. $w_2 = 0(Female)$).

◆ **Mediator-Classroom Behavioral Engagement** (mean: 3.94, SD: 0.81)

◆ **Outcome-Math Semester Grade** (mean: 82.64, SD: 12.19)

Methods

◆ Definition of Causal Effects

Natural Indirect Effect (NIE)

Change in math performance solely attributable to the growth mindset-induced change in engagement when growth mindset is held at the high level.

$$Y_i(t_1, M_i(t_1)) - Y_i(t_1, M_i(t_2))$$

	High growth mindset $T_i = t_1$	Low growth mindset $T_i = t_2$
Engagement if assigned to high growth mindset $M_i(t_1)$	$Y_i(t_1, M_i(t_1))$	
Engagement if assigned to low growth mindset $M_i(t_2)$	$Y_i(t_1, M_i(t_2))$	$Y_i(t_2, M_i(t_2))$

Natural Direct Effect (NDE)

The growth mindset effect on math achievement when math engagement is kept at the level that would be realized at a low growth mindset.

$$Y_i(t_1, M_i(t_2)) - Y_i(t_2, M_i(t_2))$$

Moderated mediation effect: A difference between the conditional NIE by two different levels of moderators.

◆ Identification of Causal Effects

- Stable Unit Treatment Value Assumption (SUTVA)
 - ✓ No interference between treatment conditions
 - ✓ No multiple versions of treatment conditions.
- Sequential Ignorability within Levels of Moderators
 - ✓ Given the pretreatment covariates, the treatment is independent of potential mediators and potential outcomes.
 - ✓ Given the pretreatment covariates, the mediator value under is independent of potential outcomes within a treatment condition or across treatment conditions.

◆ Sensitivity analysis

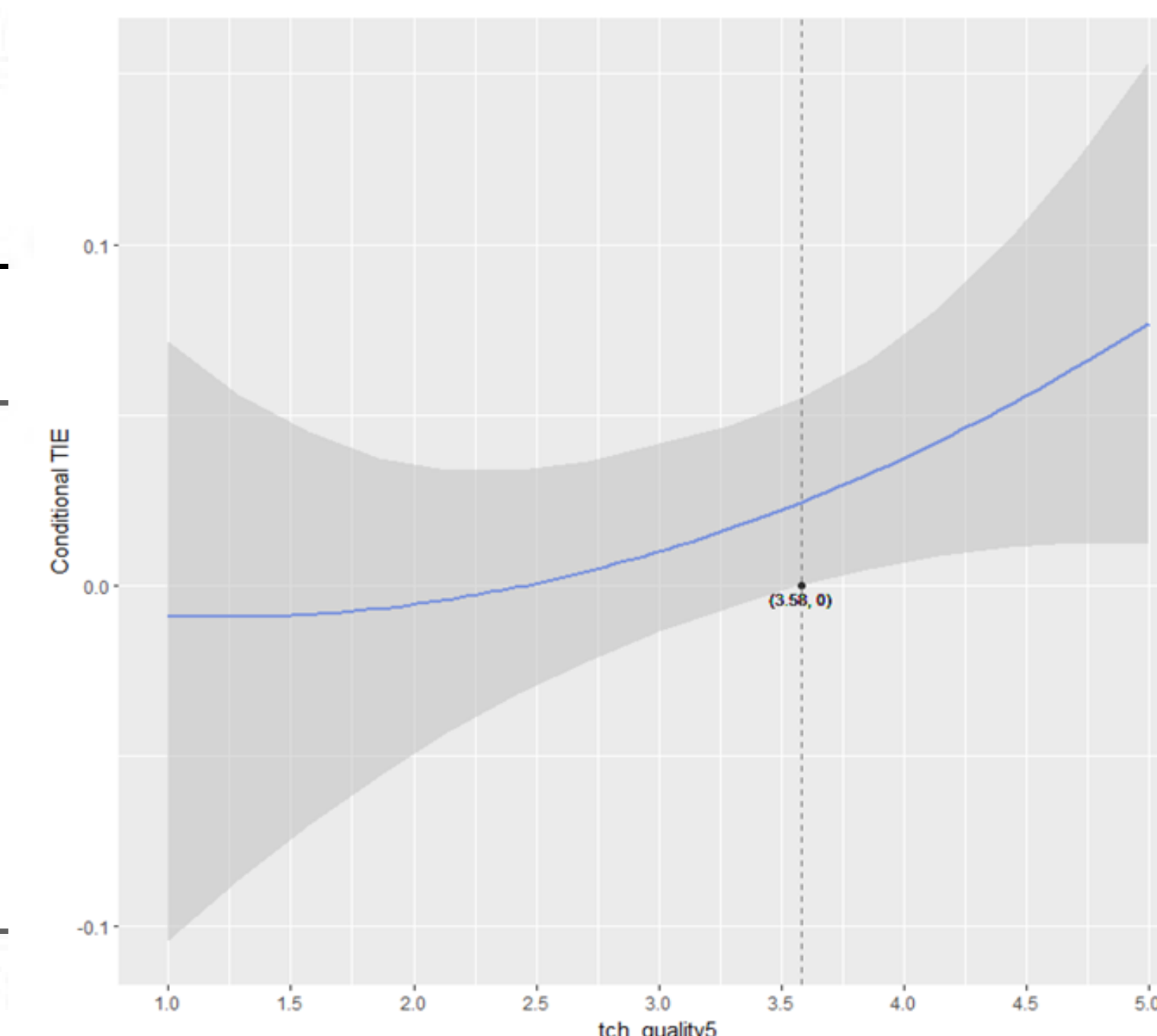
- Assess the influence of an unmeasured pretreatment confounder at a given strength by simulating it from its conditional distribution.

Analysis Results

Table 4: The pooled estimated population average causal effects ($t_1 = 4.86$ vs. $t_2 = 2.81$) moderated by teaching quality ($w_1 = 4.69$ vs. $w_2 = 3.14$) and sex ($w_1 = 1(Male)$ vs. $w_2 = 0(Female)$)

	Estimate (SE)	Effect size
NIE	0.50*(0.20)	0.0414
NDE	0.55(0.72)	0.0453
Moderated NIE by teaching quality	0.62†(0.36)	0.0513
Moderated NIE by biological sex	-0.30(0.28)	-0.0239

Note: * $p < 0.05$, † $p < 0.10$. Effect size is calculated by standardizing both independent and dependent variables.



Sensitivity Analysis Results

- ◆ Assuming no posttreatment confounder of the mediator-outcome relationship, we conducted a simulation-based sensitivity analysis to assess the influence of unmeasured pretreatment confounding.
- ◆ The results show that the sign and significance of the original causal effects would not be reversed even if there were a strong unmeasured pretreatment confounder, indicating the robustness of results to unmeasured pretreatment confounders.

Discussion

◆ Implications

- Classroom behavioral engagement significantly mediated the impact of growth mindset on math performance.
- Such a mediation mechanism differed by contextual support and student characteristics.
- The growth mindset intervention does not work universally across people and contexts.
- The growth mindset intervention is not a panacea. A high-quality classroom environment (e.g., teaching quality) is a prerequisite for the growth mindset to work.

◆ Limitations

- Failures to account for posttreatment confounders may cause bias.
- The assumption of "no interference between individuals" may be questioned because high and low growth mindset holders may be in the same school.
- The results applied to students in public schools in a U.S. metropolitan area, so it does not represent the results for the whole students in the U.S.

R Package for Causal Moderated Mediation Analysis

moderate.mediation



Contact

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