

Abstract

Noncognitive variables are important indicators for students' achievement. The study examines the relationship between noncognitive variables and science achievement using PISA 2015 data at both student- and school-level for the United State and China. The findings show most noncognitive variables have significant impacts on science outcomes and have same patterns in both countries at student-level. The effects of some of these variables also vary significantly across schools. Additionally, we also see that there are differences between two countries in terms of how noncognitive variables affect students' science achievements. And schools appear to be more important for Chinese students.

Introduction

There is an increasing interest to explore the relationship between noncognitive variables and academic achievement in educational research. Noncognitive is defined as traits or skills not captured by assessments of cognitive ability and knowledge (West et al., 2016). Previous empirical findings have shown that Noncognitive variables have potential influence on student academic achievement, such as self-efficacy, test anxiety (Stankov, 2013, Pipere & Mieriņa, 2017, Lee, 2009). However, most studies only focused on students. Schools play an important role in developing students' noncognitive skills as well. They shape students' behavior, support mental health and provide sufficient resources for the students' well-being. Therefore, we would like to address research questions to test the relationship at both student- and school-level:

- 1) Which noncognitive variables are significant predictors of student science achievement?
- 2) Do noncognitive variables have impacts on achievement vary among schools?
- 3) Do school effects (i.e. school SES) have impact on the relation between noncognitive variables and achievement?

For comparison aim, students in two regions, Confucian Asia and Western countries, show differences with respect to noncognitive variables (Morony et al., 2013, OECD, 2017). These results may be suggestive that Noncognitive variables in the United States of America and China may have different influence on student academic performance. Thus, we address the fourth research question:

- 4) What differences and similarities of the relationships between Noncognitive variables and student achievement between the United States and China?

Methods

PARTICIPANTS: The sample in this study was selected from the Program for International Student Assessment (PISA) 2015 dataset. We got 4877 students from the United States and 9740 students from China are 15 years old. (There is low proportion of missing so that we used complete cases for analysis for now.)

VARIABLES: We used 10 plausible values as outcome measures for students' science achievements. Plausible values (PV) "are a representation of the range of abilities that a student might reasonably have" (Wu & Adams, 2002). The purpose of using PVs is to deal with uncertainty and measurement error in large-scale assessment. Noncognitive variables and covariates we used in the study are shown in the following table.

Student-level:		
▪ Science self-efficacy	▪ Epistemological beliefs	▪ Instrumental motivation
▪ Enjoyment of science	▪ Environmental awareness	▪ Achieving motivation
▪ Interest in broad science topics	▪ Environmental optimism	▪ Test anxiety
School-level:		
▪ School social-economic status	▪ School size	▪ Public/Private school
Covariates: Gender, Age and Centered Student social-economic status (SES)		

PROCEDURES: We applied the Hox framework (2002) to develop our two-level HLM model. We started with the null model, then added all theoretically important level-1 predictors as fixed effects. Then we added theoretically important level-2 predictors to explain the intercept. After this step, we examined each level-1 predictor to see if it has a random component. Then we kept the random components if they showed to significant and added level-2 predictors to explain why the slopes vary across different schools. We used HLM7.0 software.

Noncognitive Variables and Science Achievement in the United States and China: Evidence from PISA 2015

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Results

	USA	China
Unconditional ICC	17.18%	52.38%
Estimate		
For intercept β_0		
Intercept (γ_{00})	426.285 ** (63.058)	455.571 *** (52.364)
School size (γ_{01})	0.0016 (0.0025)	0.0027 * (0.001)
Private school (γ_{02})	-15.369 (8.920)	-14.607 (7.996)
School SES (centered) (γ_{03})	45.119 *** (4.417)	73.074 *** (3.623)
For Gender (Male = 1) slope β_1		
Intercept (γ_{10})	-2.082 (2.538)	-10.315 *** (1.719)
For Age slope β_2		
Intercept (γ_{20})	4.444 (3.984)	5.270 (3.356)
For Student SES (group-mean centered) slope β_3		
Intercept (γ_{30})	12.958 *** (1.750)	4.646 *** (1.029)
For Environmental awareness slope β_4		
Intercept (γ_{40})	4.469 *** (1.369)	5.794 *** (1.173)
School SES (centered) (γ_{41})	-3.023 (2.337)	-5.748 *** (1.311)
For Environmental optimism slope β_5		
Intercept (γ_{50})	-13.559 *** (1.091)	-3.354 *** (0.566)
For Enjoyment of science slope β_6		
Intercept (γ_{60})	13.688 *** (1.468)	6.646 *** (1.291)
For Interest in broad science slope β_7		
Intercept (γ_{70})	1.635 (1.467)	5.635 *** (1.195)
For Science self-efficacy slope β_8		
Intercept (γ_{80})	5.017 *** (1.289)	0.186 (0.925)
School SES (centered) (γ_{81})	6.971 *** (2.098)	1.777 (1.126)
For Epistemological beliefs β_9		
Intercept (γ_{90})	15.823 *** (1.332)	11.521 *** (1.415)
For Test anxiety slope β_{10}		
Intercept (γ_{100})	-12.329 *** (1.520)	-11.123 *** (1.157)
School SES (centered) (γ_{101})	3.595 (2.550)	3.873 ** (1.462)
For Achieving motivation slope β_{11}		
Intercept (γ_{110})	4.231 ** (1.501)	6.678 *** (1.133)
School SES (centered) (γ_{111})	-2.055 (2.832)	-7.047 *** (1.485)
For Instrumental motivation β_{12}		
Intercept (γ_{120})	-7.792 *** (1.421)	-8.483 *** (1.158)

*** p < 0.001; ** p < 0.01; * p < 0.05. Standard error is shown in the parentheses. Highlight means the level-1 predictor has a significant random component.

- ICC are very different in two countries. In China, there is more than half of the variance is between-schools, while in USA, only less than 20% variance is at the school-level.
- Most of the noncognitive variables in our study have statistically significant effects on students' science achievements in both countries. The two exceptions are Interest in broad science only has a positive effect for Chinese students while Science self-efficacy only has a positive effect on American students.
- Some noncognitive variables have impacts vary among schools. Environmental awareness, Science self-efficacy and Achieving motivation show significance in USA. Environmental awareness, Test anxiety and Achieving motivation show significance in China.
- Cross-level interactions also appear in the analysis. In USA, School SES affects how Science-efficacy influences students' achievements. In China, School SES affects how Environmental Awareness, Test Anxiety as well as Achieving motivation influences students' achievements.

Model

Level 1 Student-Level:

$$Science_{ij} = \beta_{0j} + \beta_{kj}Noncog_{ij} + \beta_{tj}Stucov_{ij} + r_{ij}$$

where $k = 3, 4, \dots, 11; t = 1, 2;$

Level 2 School-Level:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}Schsize_j + \gamma_{02}Private_j + \gamma_{03}SchSES_jU_{0j}$$

$$\beta_{1j} = \gamma_{10} + U_{1j}$$

$$\beta_{2j} = \gamma_{20} + U_{2j}$$

Discussion

1. One of the largest differences among two countries is that China has a more than twice larger between-school variance than that in USA. This is consistent with the coefficient estimates for the school-level and student-level SES. China has a larger coefficient for school-level SES while USA has a larger coefficient for student-level SES. Additionally, we also find that China has more level-1 predictors with significant random slopes across schools. This indicates schools play a more important role in students' achievement in China.

2. Analyses for Noncognitive variables

- ❖ Environmental issues are global concerns. Environmental awareness has shown positive effects and Environmental optimism has negative effects on students' science achievement in both two countries. That is, the more concerned students are about environmental issues, the higher their academic outcomes. Additionally, Environmental optimism for USA has a larger effect than in China. And Chinese students from high SES schools are less affected by Environmental awareness.
- ❖ Enjoyment of science & Epistemological beliefs have shown positive associations with science achievements.
- ❖ Test anxiety has shown negative effects on students' science achievement in both USA and China. The negative effect of Test anxiety is more serious for low SES school students in China.
- ❖ Self-efficacy has been known as a very important indicator for achievement. However, there is no significant associations between Chinese students' science achievement and their Science self-efficacy. But it is significant for American students.
- ❖ For both countries, Achieving motivation has a positive effect while Instrumental motivation has a negative effect. This reflects that different types of motivations can affect students' academic performance differently. Moreover, achieving motivation makes a larger difference in low SES schools in China.

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