A Cross-National Study of Mathematics Achievement via Three-Level Multilevel Models

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Abstract
The present study explored the effects of the national and cultural contexts on students' mathematics achievement. The study also investigated the nature and magnitude of student-level (level 1), school-level (level 2), and country-level (level 3) factors that are associated with math achievement. The Program for International Student Assessment (PISA) 2018 datasets were used. The findings of HLM analysis showed that mathematics achievement is associated with national and cultural contexts since the study found 31.30% of the total variation was accounted for level 3 in math achievement. Also, the study found that various predictors were statistically significant for explaining math achievement. Moreover, the study found several counterintuitive association phenomena due to the shift of meaning. These findings were explained regarding practical and theoretical implications for policymakers, educators, and researchers to improve students' mathematics achievement.

Keywords: Mathematics Achievement, Hierarchical Linear Modeling (HLM), Information and Communication Technology (ICT), Compositional Effects

Introduction

The primary goal of the study is to explore the effects of the national and cultural contexts on students' mathematics achievement. Then, the nature and magnitude of country-level factors, as well as school- and student-level factors that are associated with math achievement was examined by using HLM analysis. Exploring country-level factors that contribute to the variation has been largely ignored in educational studies due to a lack of country-level data. Accordingly, studies investigating students' academic achievement heavily focus on the individual- and school-level factors. This study hypothesized that national and cultural characteristics are associated with math achievement. Also, the study hypothesized that there are several compositional factors strongly associated with math achievement as well. The specific research questions are presented in the following:

1. Is there significant variability in mathematics achievement across schools and countries? If so, how will total variation be allocated to student-, school-, and country-level?
2. How are country-level variables associated with the country-mean student's mathematics achievement?
3. Are there any school-level and country-level compositional factors strongly associated with mathematics achievement?

Theoretical Framework

The theoretical framework of this study is built on the multilevel paradigm. The development of multilevel analysis (Bryk & Raudenbush, 1992) and multilevel analysis software have promoted a multilevel paradigm in educational research. Since multilevel data should be explained by multilevel theories, researchers must define which direct effects and cross-level interaction effects can be expected in their studies by articulating specific theoretical models (Hox & Van, 2017). A cross-national study will be conducted in this study. Therefore, the study requires cross-level theorizing by identifying country-level characteristics that are associated with an individual- or group-level response (Tsui et al., 2007). Also, the hypothesis of the study is that country characteristics influence student achievement is underpinned by social cognitive theory (Bandura, 1986) and sociocultural theory (Vygotsky, 1978). Bandura's social cognitive theory stresses that learning occurs in social contexts with the interaction between personal factors and behavior (Bandura, 1986). Vygotsky's sociocultural theory emphasizes the influence of social interaction and culture in learning. Underpinned by both theories, this study hypothesized that mathematics achievement is influenced by not only individual characteristics but also environmental contexts.

Data

The data used in this study were obtained from the Programme for International Student Assessment (PISA) 2018, conducted by Organisation for Economic Cooperation and Development (OECD). Originally, PISA 2018 consisted of assessment of 612,004 students from 79 countries. In this study, 58 countries were selected for analysis. The number of students ranges from 3,209 to 34,925 and the number of schools ranges from 48 to 825. In this study, mathematics literacy results and variables from students' and schools' questionnaires in PISA2018 were used as student- and school-level. For country-level variables, data from various global reports and variables created by aggregating the school-level variables were used. As a dependent variable, the average 10 parameter estimates from the 10 plausible values (PVs) of mathematics proficiency was used.

Methodology

The analyses started with generating correlation matrixes between all variables in each level and the dependent variable. Then, hierarchical linear models (HLM) were implemented to explore the relationship between student-level, school-level, and country-level predictors and mathematics achievement. A three-level HLM was used as a primary analytic methodology in this study since the data has a nested structure, with students nested within schools, which in turn nested within countries. The HLM analysis of this study began with a fully unconditional model to determine whether the HLM is appropriate for the data. The fully unconditional model was formulated using mathematic achievement as an outcome variable with no level 1, level 2, or level 3 predictors. The HLM equations of the fully unconditional models are represented as follows:

Equation 1. *Equations for Unconditional Model*

Student-Level (Level 1) Model:

$$\text{PVMATH}_{\text{ijk}} = \pi_{0\text{jk}} + e_{\text{ijk}}.$$

School-Level (Level 2) Model:

$$\pi_{0\text{jk}} = \beta_{00\text{k}} + \gamma_{0\text{jk}}.$$

Country-Level (Level 3) Model:

$$\beta_{00\text{k}} = \gamma_{000} + u_{00\text{k}}.$$

After running the unconditional model, the conditional model was built by adding all student-level, school-level, and country-level predictors. All the predictors in the country-level (level 3) were centered at grand-mean. Centering around grand mean at level 3 allows us to improve the interpretation of the intercept values. All the student-level (level 1) and school-level (level 3) variables were group-mean centered. When group-mean centering of the student-level predictors is used, the student-level predictor coefficients (γ_{k00}) represent within-school effects and the school-level predictor coefficients (γ_{0k0}) represent within-country effects.

Equation 2. *Equations for Conditional Model*

Student-Level (Level 1) Model:

$$\text{PVMATH}_{\text{ijk}} = \pi_{0\text{jk}} + \pi_{1\text{jk}}(FEM_{ijk}) + \pi_{2\text{jk}}(PARED_{ijk}) + \pi_{3\text{jk}}(ICT_{ijk}) + \pi_{4\text{jk}}(PARES_{ijk}) + \pi_{5\text{jk}}(BELN_{ijk}) + \pi_{6\text{jk}}(RSELF_{ijk}) + \pi_{7\text{jk}}(MAG_{ijk}) + \pi_{8\text{jk}}(FFAIL_{ijk}) + \pi_{9\text{jk}}(OA_{ijk}) + \pi_{10\text{jk}}(VSCH_{ijk}) + \pi_{11\text{jk}}(GM_{ijk}) + e_{\text{ijk}}$$

School-Level (Level 2) Model:

$$\pi_{0\text{jk}} = \beta_{00\text{k}} + \beta_{01\text{k}}(RURAL_{jk}) + \beta_{02\text{k}}(CITY_{jk}) + \beta_{03\text{k}}(PRIV_{jk}) + \beta_{04\text{k}}(STR_{jk}) + \beta_{05\text{k}}(PFT_{jk}) + \beta_{06\text{k}}(CSIZE_{jk}) + \beta_{07\text{k}}(CREA_{jk}) + \beta_{08\text{k}}(SBHL_{jk}) + \beta_{09\text{k}}(TBHL_{jk}) + \beta_{010\text{k}}(XFEM_{jk}) + \beta_{011\text{k}}(XPARED_{jk}) + \beta_{012\text{k}}(XICT_{jk}) + \beta_{013\text{k}}(XPARES_{jk}) + \beta_{014\text{k}}(XBELN_{jk}) + \beta_{015\text{k}}(XRSELF_{jk}) + \beta_{016\text{k}}(XMAG_{jk}) + \beta_{017\text{k}}(XFFAIL_{jk}) + \beta_{018\text{k}}(XOA_{jk}) + \beta_{019\text{k}}(XVSCH_{jk}) + \beta_{020\text{k}}(XGM_{jk}) + \gamma_{0\text{jk}}.$$

$$\pi_{1\text{jk}} = \beta_{10\text{k}}$$

$$\pi_{2\text{jk}} = \beta_{20\text{k}}$$

$$\pi_{3\text{jk}} = \beta_{30\text{k}}$$

$\pi_{4jk} = \beta_{40k}$
$\pi_{5jk} = \beta_{50k}$
$\pi_{6jk} = \beta_{60k}$
$\pi_{7jk} = \beta_{70k}$
$\pi_{8jk} = \beta_{80k}$
$\pi_{9jk} = \beta_{90k}$
$\pi_{10jk} = \beta_{100k}$
$\pi_{11jk} = \beta_{110k}$

Conclusions

All results for the model can be found in the Table 5. In the fully unconditional model, the average mathematics achievement score (the intercept at level 1) is estimated to be 417.49. The estimated variance components from the model were σ^2= 4506.93, τ_π= 2916.65, and τ_β= 3382.67 at the student, school, and country level (Table 6.). this model found that 41.71% of the variation in mathematics achievement was due to difference among students, and 26.99% of the total variance in math achievement was attributable to differences among schools. Lastly, 31.30% of the variance in math achievement was accounted for by difference among countries. Since the school variance component and country variance component are both significant and the variability in math achievement at the school- and country-level were large, conducting a HLM is necessary to be processed.

In the conditional model (See Table 5), the strict university admission system, the country-mean city, country-mean proportion of fully certified teacher, country-mean teacher behavior hindering learning, and country-mean ICT usage were positively associated with math achievement while country-mean student-teacher ratio, country-mean parental education level, and country-mean resilience self-efficacy were negatively associated with math achievement. One of interesting findings from the final model was that the partial correlation between country-mean resilience self-efficacy and country-mean students' math achievement became negative after controlling for other predictors in the model which was opposite of the results of the correlation matrix among the student-level predictors with the dependent variable. Figure 1 shows the scatterplot show the marginal correlation between student's resilience self-efficacy and math achievement with regression lines based on 58 countries. As shown in the Figures, student's resilience self-efficacy and math achievement had a positive relationship. This indicates that students who believe more strongly in their ability to cope with difficult or challenging experience show higher math achievement. From results of the conditional model, several compositional effects were detected for school- and country-level. Firstly, there was only one factor that compositional effects were detected from both school- and country-level, which was ICT usage. Meanwhile, the following three variables that were showed school compositional effects on math achievement: parents' emotional support, occupational aspiration, and growth mindset.

On the other hand, Figure 2 shows the scatterplot of country-mean resilience self-efficacy against country-mean math achievement. This figure does not indicate students with lower resilience self-efficacy show higher math achievement. Instead, shift of meaning plays a role in the macro-level relationship. The meaning of resilience self-efficacy variable that is aggregated to the country-level distinct from the meaning of student-level resilience self-efficacy. The occurrence of counterintuitive association might be due to shift of meaning. If we make inferences about student's resilience self-efficacy based on country-mean resilience self-efficacy, an ecological fallacy may occur by ignoring the disparity between the country-level and student-level. The country-mean resilience self-efficacy refers to the cultural context of country. In the other word, the country-mean resilience self-efficacy means beliefs and values that are shared among people in a country. As shown in the Figure, East Asian countries generally show low country-mean resilience self-efficacy while those countries show high country-mean math achievement. This may represent cultural characteristics of those countries.

Second finding of this study was that the country-mean parental education level had a negative association with country-mean students' math achievement. This result was opposite to majority of previous literature that parents' education is positively associated with their children's academic outcomes. The study found that the coefficient for country-mean parental education level went from positive to negative when the country-mean ICT usage was added as the sole predictor. Scatterplots describing the relationship between country-mean parental education and country-mean math achievement were created to understand the results of the model. As shown in Figure 3, a group of countries have high level of country-mean ICT usage (larger than 50th percentile) showed a negative relationship between country-mean parental education and country-mean math achievement while a group of countries have low level of country-mean ICT usage (smaller than 50th percentile) showed a positive relationship between country-mean parental education and country-mean math achievement. This situation in which a relationship observed at the group reverse is known as Simpson's paradox (Blyth, 1972). The results of the model found that country-mean ICT usage plays a role as a confounding variable which reversed the association between country-mean parental education and country-mean math achievement.

Also, the final model found that country-mean teacher behavior hindering learning which represents school climate in school-level predictors had positive association with students' math achievement after controlling for other predictors in the model. As shown in school-level correlation matrix from Table 3, there was a negative correlation between the school-level teacher behavior hindering learning variable and school-mean students' math achievement. Figure 4 shows the scatterplot displaying the relationship teacher behavior hindering learning variable and school-mean students' math achievement. Such counterintuitive association phenomena may be due to shift of meaning. It shows that meaning of a micro-level variable aggregated to the macro-level is distinct from the micro-level variable. The average of the school-level variables may be used as an index for countries' cultural climate; hence higher scores of the country-mean teacher behavior hindering learning from countries may represent greater level of standard for school climate. In other words, country-mean teacher behavior hindering learning may represent the level of standard for teacher in countries. Figure 5 shows the scatter plot regarding relationship between country-mean teacher behavior hindering learning and country-mean math achievement. As shown in the scatter plot, East Asian countries including China, Chinese Taipei, Hong Kong, Singapore, Japan, and Korea generally higher than other countries. This may indicate that East Asian countries have higher standard for teacher behaviors.

The findings of the study provide important practical and theoretical implications for policy makers, educator, and researchers. First, the findings supported the hypothesis of this study that mathematics achievement was associated with national and cultural contexts because the study found 31.30% of the total variation was accounted for country level in math achievement. This result provided a justification that country characteristics should be examined in a context of cross-national comparison study.

One of the unique findings of the present study was that the shift of meaning played important roles in interpreting the country-mean teacher behavior hindering learning in the conditional model. The meanings of the variable were apparently distinct from the meanings as school-level variable. The country-mean teacher behavior hindering learning can be used as index for ‘national standard for teacher’.

Also, the study found that the country-mean ICT usage played a role as a confounding variable which reversed the sign of the correlation between the country-mean parental education level and country-mean math achievement. The finding indicates that the school-mean ICT usage and country-mean ICT usage promote student’s math achievement even after controlling for student-level predictors. This finding provided strong evidence in supporting previous research that ICT plays an important role in student’s academic achievement. Accordingly, the finding provided practical implication for educators and policy makers that supporting ICT resources and providing good learning environment through ICT to students would facilitate student’s mathematics achievement.

Appendices

	Name	Description	Valid N	Distribution			
				Min	Max	Mean	SD
Y	PVM1	Plausible Value 1 in Mathematics	455,206	24.74	864.60	456.67	105.28
	PVM2	Plausible Value 2 in Mathematics	455,206	25.56	892.73	456.59	105.39
	PVM3	Plausible Value 3 in Mathematics	455,206	53.19	910.44	456.57	105.38
	PVM4	Plausible Value 4 in Mathematics	455,206	29.97	870.64	456.67	105.52
	PVM5	Plausible Value 5 in Mathematics	455,206	8.27	915.10	456.39	105.60
	PVM6	Plausible Value 6 in Mathematics	455,206	5.22	870.20	456.48	105.41
	PVM7	Plausible Value 7 in Mathematics	455,206	3.21	883.59	456.81	105.59
	PVM8	Plausible Value 8 in Mathematics	455,206	0.00	889.80	456.65	105.39
	PVM9	Plausible Value 9 in Mathematics	455,206	26.58	899.89	456.45	105.43
	PVM10	Plausible Value 10 in Mathematics	455,206	24.92	894.59	456.59	105.57
X_1	FEM	Student Gender	455,206	0.00	1.00	0.50	0.50
	PARED	Highest parental education in years of Schooling	455,206	3.00	18.00	13.52	3.10
	ICT	ICT resources	455,206	-4.01	4.01	-0.45	1.16
	PARES	Parents' emotional support perceived by student	455,206	-2.45	1.03	-0.05	0.94
	BELN	Sense of belonging to school	455,206	-3.32	3.23	-0.07	0.94
	RSELF	Resilience	455,206	-3.17	2.77	0.07	0.99
	MAG	Mastery goal orientation	455,206	-2.53	1.85	0.14	1.01
	FFAIL	General fear of failure	455,206	-1.89	1.89	-0.03	0.95
	OA	Expected occupational status	455,206	-3.12	1.27	-0.01	1.00
	VSCH	Attitudes towards learning activities	455,206	-2.54	1.08	0.03	0.98
	GM	Growth mindset	455,206	-1.75	1.54	0.00	1.00
X_2	XFEM	Proportion of females in school	13,519	0.00	1.00	0.49	0.22
	XPARED	Mean of student level parental education level	13,519	3.00	18.00	13.42	1.79
	XICT	Mean of student level ICT usage	13,519	-3.96	2.10	-0.51	0.81
	XPARES	Mean of student level perceived parents 'emotional support	13,519	-2.45	1.03	-0.07	0.39
	XBELN	Mean of student level sense of belonging in school	13,519	-3.24	3.22	-0.09	0.38
	XRSELF	Mean of student level resilience self-efficacy	13,519	-3.17	2.70	0.04	0.39
	XMAG	Mean of student level mastery goal orientation	13,519	-2.53	1.85	0.13	0.46
	XFFAIL	Mean of student level fear of failure	13,519	-1.89	1.89	-0.04	0.36
	XOA	Mean of student level occupational aspiration	13,519	-3.09	1.25	-0.07	0.60
	XVSCH	Mean of student level belief in the value of school	13,519	-2.54	1.08	0.01	0.34
	XGM	Mean of student growth mindset	13,519	-1.75	1.54	-0.00	0.39
	RURAL	Location of the school (Rural=1, Town =0)	13,519	0.00	1.00	0.34	0.47
	CITY	Location of the school (City=1, Town=0)	13,519	0.00	1.00	0.39	0.49
	PRIV	Type of school (Public=0, Private=1)	13,519	0.00	1.00	0.20	0.40
	STR	Student-teacher ratio	13,519	0.01	0.90	0.14	0.83
	PFCT	Proportion of fully certified teachers	13,519	0.00	1.00	0.80	0.34
	CSIZE	The number of students in one classroom	13,519	13.00	53.00	27.72	10.45
	EXTRA	The number of extra-curricular activities at school	13,519	0.00	3.00	1.85	1.03
	SBHL	student-related factors affecting school climate	13,519	-4.35	3.63	0.01	1.26
	TBHL	teacher-related factors affecting school climate	13,519	-2.09	3.83	0.12	1.16
X_3	YFEM	Proportion of females in the country	13,519	0.46	0.54	0.50	0.02
	YPARED	Mean of the school level parental education level	58	10.89	16.63	13.49	1.18
	YICT	Mean of school level access to ICT resources usage	58	-1.93	0.59	-0.51	0.63
	YPARES	Mean of school level perceived parents' emotional support	58	-0.46	0.32	-0.06	0.16
	YBELN	Mean of school level school engagement	58	-0.40	0.46	-0.10	0.19
	YRSELF	Mean of school level resilience self-efficacy	58	-0.61	0.60	0.06	0.22
	YMAG	Mean of school level mastery goal orientation	58	-0.34	0.67	0.14	0.28
	YFFAIL	Mean of school level fear of failure	58	-0.42	0.67	-0.04	0.23
	YOA	Mean of school level student occupational aspirations	58	-0.54	0.47	-0.04	0.48
	YVSCH	Mean of school level belief in the value of school	58	-0.46	0.51	0.01	0.21
	YGM	Mean of school level growth mindset	58	-0.64	0.43	-0.01	0.20
	YRURAL	Proportion of rural in the country	58	0.00	0.71	0.34	0.17
	YCITY	Proportion of city in the country	58	0.00	1.00	0.39	0.19
	YPRIV	Mean of school level type of school	58	0.00	0.90	0.18	0.20
	YSTR	Mean of school level student-teacher ratio	58	0.07	0.25	0.13	0.45
	YPFCT	Mean of school level proportion of fully certified teacher	58	0.29	0.97	0.79	0.17
	YCSIZE	Mean of school level class size	58	16.75	38.93	25.10	5.07
	YEXTRA	Mean of school level extra-curricular activities in school	58	-1.24	1.09	0.02	0.44
	YSBHL	Mean of school level student behavior hindering learning	58	-1.53	0.90	-0.07	0.47
	YTBHL	Mean of school level teacher behavior hindering learning	58	1.02	2.82	1.81	0.45
	OECD	Member of OECD (OECD=1, No OECD=0)	58	0.00	1.00	0.41	0.50
	STRICT	Types of admission procedure in higher education (Strict system=1, Flexible system=0)	58	0.00	1.00	0.90	0.31
	GDP	GDP per capita in 2018 (in U.S dollar) Divided into 10,000	58	0.32	8.64	2.42	2.10
	GG	Global Gender Gap Report from World Economic Forum (as %)	58	0.58	0.88	0.71	0.05
	GINI	GINI index measured the degree of inequality in the distribution of family income in a country (as %). Revers coded.	58	0.46	0.76	0.64	0.07

Table 1. Summary of variables in the final sample

	XFEM	XPARED	XICT	XPARES	XBELN	XRSELF	XMAG	XFFAIL	XOA	XVSCH	XGM	STR	PFCT	CSIZE	EXTRA	SBHL	TBHL	RURAL	CITY	PRIV	XPM1~ XPM10
XFEM	1																				
XPARED	.015	1																			
XICT	.035**	.623**	1																		
XPARES	.184**	.176**	.223**	1																	
XBELN	.103**	.170**	.186**	.424**	1																
XRSELF	.060**	.007	.011	.419**	.375**	1															
XMAG	.122**	-.113**	-.254**	.302**	.117**	.480**	1														
XFFAIL	.113**	.059**	.145**	.035**	-.159**	-.123**	-.040**	1													
XOA	0	-.089**	-.101**	.038**	-.004**	.121**	.178**	-.008**	1												
XVSCH	.147**	-.028**	.012	.359**	.314**	.263**	.373**	.032**	.269**	1											
XGM	.067**	.258**	.378**	.137**	.163**	-.050**	-.142**	-.015	.118**	.078**	1										
STR	.043**	-.134**	-.232**	-.005	-.080**	.046**	.154**	.061**	.152**	.116**	-.017*	1									
PFT	-0.014	.028**	.075**	-.024**	.008	-.134**	-.159**	.038**	-.085**	-.045**	.068**	-.065**	1								
CSIZE	.086**	-.101**	-.146**	.031**	-.033**	.084**	.119**	.111**	.223**	.110**	-.043**	.366**	-0.001	1							
EXTRA	.097**	.107**	.155**	.154**	-.016	.047**	.042**	.153**	.122**	.049**	.103**	.021*	.058**	.097**	1						
SBHL	-.066**	-.150**	-.112**	-.139**	-.129**	-.069**	-.065**	-.077**	-.165**	-.081**	-.025**	.064**	.052**	.040**	-.103**	1					
TBHL	-.012	-.050**	-.026**	-.034**	-.060**	-.032**	0.005	-.016	.008	.017	.037**	.041**	0.012	.075**	-.039**	.640**	1				
XRURAL	-.030**	-.243**	-.255**	-.069**	-.042**	-.035**	.074**	-.137**	-.165**	-.037**	-.184**	-.146**	-0.01	-.237**	-.120**	-0.01	-.044**	1			
XCITY	.021*	.215**	.210**	.075**	.031**	.048**	0.01	.142**	.197**	.033**	.161**	.110**	-.021*	.204**	.124**	-.029**	.042**	-.577**	1		
XPRIV	.010	.242**	.257**	.150**	.124**	.089**	.022*	.128**	.174**	.127**	.087**	.056**	-.172**	.019*	.064**	-.212**	-.084**	-.189**	.209**	1	
XPM1	.085**	.464**	.609**	.262**	.252**	-.046**	-.215**	.205**	.182**	.002	.388**	-.179**	.160**	-.036**	.242**	-.202**	-.046**	-.229**	.205**	.157**	1
XPM2	.083**	.464**	.606**	.263**	.255**	-.044**	-.209**	.203**	.185**	.003	.390**	-.180**	.161**	-.037**	.240**	-.202**	-.044**	-.229**	.205**	.160**	1
XPM3	.082**	.462**	.608**	.263**	.252**	-.043**	-.214**	.206**	.185**	.003	.386**	-.177**	.162**	-.036**	.241**	-.203**	-.048**	-.233**	.206**	.160**	1
XPM4	.082**	.460**	.606**	.262**	.251**	-.048**	-.215**	.208**	.178**	.004	.388**	-.178**	.161**	-.035**	.241**	-.203**	-.045**	-.231**	.206**	.160**	1
XPM5	.080**	.461**	.608**	.264**	.255**	-.041**	-.210**	.204**	.181**	.003	.385**	-.180**	.160**	-.038**	.240**	-.204**	-.047**	-.229**	.206**	.162**	1
XPM6	.084**	.460**	.606**	.261**	.253**	-.046**	-.213**	.205**	.183**	.003	.388**	-.177**	.163**	-.035**	.241**	-.203**	-.046**	-.233**	.207**	.158**	1
XPM7	.084**	.459**	.605**	.262**	.252**	-.045**	-.215**	.206**	.179**	.002	.390**	-.179**	.163**	-.038**	.240**	-.201**	-.046**	-.230**	.205**	.160**	1
XPM8	.083**	.459**	.605**	.262**	.255**	-.043**	-.213**	.205**	.184**	.002	.385**	-.178**	.161**	-.035**	.241**	-.204**	-.048**	-.230**	.207**	.159**	1
XPM9	.082**	.462**	.605**	.261**	.253**	-.045**	-.212**	.205**	.183**	.001	.388**	-.178**	.164**	-.035**	.242**	-.202**	-.046**	-.229**	.206**	.156**	1
XPM10	.079**	.462**	.605**	.263**	.255**	-.044**	-.216**	.200**	.181**	.004	.387**	-.179**	.162**	-.034**	.241**	-.201**	-.044**	-.230**	.206**	.158**	1

Table 2.School Level (Level-2) Correlation Matrix (J = 13,519)

	YFEM	YPARED	YICT	YPARES	YBELN	YRSELF	YMAG	YFFAIL	YOA	YVSCH	YGM	YRURAL	YCITY	YSTR	YPRIV	YPFCT	YCSIZE	YEXTRA	YSBHL	YTBHL	OECD	STRICT	GDP	GG	GINI	YPV1~YPV10
YFEM	1																									
YPARED	-.304*	1																								
YICT	-.379**	.658**	1																							
YPARES	-0.09	0.18	.301*	1																						
YBELN	-.280*	.268*	0.21	.577**	1																					
YRSELF	0.02	-.261*	-.281*	.416**	0.24	1																				
YMAG	0.22	-.378**	-.529**	0.22	-0.10	.603**	1																			
YFFAIL	0.22	-0.08	0.15	-0.05	-.307*	-.377**	-0.17	1																		
YOA	0.20	-.354**	-.286*	0.10	-0.20	.492**	.635**	0.01	1																	
YVSCH	0.07	-0.21	-0.09	.521**	.321*	.317*	.458**	0.02	.423**	1																
YGM	-0.25	.370**	.579**	0.23	0.19	-0.23	-.397**	0.11	-0.14	0	1															
YRURAL	-0.06	0.1	-0.19	0.03	-0.04	0.16	.272*	-.399**	0.01	0	-0.19	1														
YCITY	0.07	-0.2	-0.01	-0.09	-0.08	-0.09	0.05	.466**	.268*	0.06	0.09	-.793**	1													
YSTR	.324*	-.466**	-.479**	-0.14	-0.24	0.18	.417**	0.04	.335*	0.25	-0.22	-0.11	0.09	1												
YPRIV	0.08	-0.09	0.16	0.11	-0.01	-0.08	0.00	.338**	0.19	0.22	-0.10	-.303*	.291*	0.13	1											
YPFCT	-0.07	.264*	.341**	-0.08	0.07	-.428**	-.469**	0.17	-.402**	-0.13	0.16	-0.11	-0.02	-.288*	-0.17	1										
YCSIZE	0.24	-.508**	-.353**	-0.16	-0.18	0.05	0.17	.336**	.345**	0.19	-.265*	-.583**	.604**	.364**	0.25	-0.07	1									
YEXTRA	-0.06	-0.08	0.06	-0.12	-0.19	-0.22	-0.07	0.09	0.07	0.13	0.19	-0.24	0.2	0.18	.301*	-0.05	0.19	1								
YSBHL	0.01	-0.02	-0.06	-0.26	-0.21	-0.09	-0.20	-0.13	-0.19	-0.16	0.15	-0.07	-0.1	0.25	-0.21	0.14	0.02	.647**	1							
YTBHL	-0.12	0.06	.304*	.302*	-0.03	-0.03	-0.05	.399**	-0.11	0.10	0.14	-0.18	0.1	-0.08	0.22	0.18	0.01	0.08	-0.09	1						
OECD	-0.10	0.24	.483**	0.23	.308*	-0.21	-.446**	0.1	-.286*	-0.07	.523**	-0.16	-0.1	-0.03	0.03	0.10	-0.22	-0.01	0.02	0.11	1					
UAP	0.16	-0.08	-0.17	-0.14	-0.12	-0.17	-0.06	0.2	-0.05	-0.20	-0.09	0.06	0.0	0.19	0.00	0.04	-0.05	-0.10	-0.01	0.03	0.06	1				
GDP	-0.25	.472**	.776**	.389**	.269*	-0.24	-.284*	.272*	-0.15	0.17	.470**	-0.23	0.1	-0.22	.269*	0.23	-0.20	0.12	-0.15	.333*	.483**	-0.14	1			
GG	-0.03	.376**	.299*	.330*	0.21	-0.08	-.293*	0.00	-.376**	-0.12	.335*	0.14	-.353**	-0.09	-0.15	0.19	-.411**	-0.01	0.11	0.12	.333*	0.12	.311*	1		
GINI	.262*	-.544**	-.456**	-0.12	-0.26	0.22	.432**	0.20	.607**	.339**	-0.19	-.301*	.457**	.480**	.275*	-0.18	.560**	0.18	-0.03	0.00	-.331*	-0.06	-0.13	-.278*	1	
YPM1	-.360**	.381**	.703**	0.095	0.205	-.513**	-.661**	.362**	-.466**	-.270*	.527**	-.308*	0.189	-.467**	0.1	.434**	-0.177	0.084	-0.05	.430**	.476**	0.142	.574**	.281*	.391**	1
YPM2	-.360**	.381**	.701**	0.097	0.206	-.512**	-.657**	.361**	-.465**	-.270*	.528**	-.304*	0.188	-.467**	0.097	.433**	-0.181	0.082	-0.05	.429**	.476**	0.147	.573**	.286*	.392**	1
YPM3	-.361**	.379**	.702**	0.097	0.205	-.508**	-.657**	.362**	-.463**	-.271*	.527**	-.305*	0.189	-.466**	0.096	.435**	-0.18	0.082	-0.048	.432**	.475**	0.142	.573**	.280*	.390**	1
YPM4	-.359**	.378**	.700**	0.096	0.203	-.509**	-.657**	.366**	-.466**	-.271*	.526**	-.307*	0.189	-.463**	0.096	.433**	-0.177	0.082	-0.048	.434**	.474**	0.147	.573**	.285*	.390**	1
YPM5	-.357**	.378**	.701**	0.097	0.204	-.510**	-.658**	.363**	-.465**	-.271*	.526**	-.307*	0.19	-.466**	0.099	.435**	-0.175	0.085	-0.047	.431**	.477**	0.142	.573**	.280*	.391**	1
YPM6	-.355**	.375**	.698**	0.097	0.204	-.511**	-.656**	.366**	-.462**	-.269*	.525**	-.306*	0.19	-.465**	0.099	.433**	-0.177	0.081	-0.052	.431**	.473**	0.148	.572**	.281*	.387**	1
YPM7	-.357**	.378**	.700**	0.099	0.205	-.512**	-.659**	.365**	-.467**	-.271*	.527**	-.304*	0.187	-.465**	0.096	.434**	-0.179	0.08	-0.05	.433**	.474**	0.146	.574**	.286*	.391**	1
YPM8	-.359**	.376**	.698**	0.096	0.206	-.510**	-.657**	.364**	-.465**	-.270*	.524**	-.307*	0.191	-.465**	0.094	.433**	-0.175	0.079	-0.052	.430**	.475**	0.146	.573**	.281*	.390**	1
YPM9	-.361**	.377**	.700**	0.096	0.204	-.511**	-.658**	.362**	-.465**	-.272*	.525**	-.306*	0.191	-.468**	0.098	.436**	-0.177	0.081	-0.05	.433**	.474**	0.141	.572**	.278*	.388**	1
YPM10	-.357**	.380**	.699**	0.097	0.209	-.513**	-.662**	.360**	-.468**	-.271*	.525**	-.307*	0.188	-.470**	0.094	.436**	-0.176	0.083	-0.048	.427**	.476**	0.144	.574**	.283*	.392**	1

Table 3.Country Level (Level-3) Correlation Matrix (K = 58)

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

	Fully unconditional model	Conditional model
Fixed Effects		
Intercept, γ_{000}	417.49***	450.11***
OECD, γ_{001}		18.02
STRICT, γ_{002}		25.89*
GDP, γ_{003}		1.01
GG, γ_{004}		153.97
GINI, γ_{005}		68.30
Country-mean Rural, γ_{006}		92.12
Country-mean City, γ_{007}		94.02*
Country-mean Private School, γ_{008}		33.15
Country-mean Student-Teacher Ratio, γ_{009}		-366.06**
Country-mean Proportion of Fully Certified Teachers, γ_{0010}		56.67*
Country-mean Class Size, γ_{0011}		-0.20
Country-mean Extra-Curricular Activities in School, γ_{0012}		-13.93
Country-mean Student Behavior Hindering Learning, $\gamma 0_{013}$		24.42
Country-mean Teacher Behavior Hindering Learning, γ_{0014}		36.61***
Country-mean Female, γ_{0015}		-263.69
Country-mean Parental Education Level, γ_{0016}		-14.45**
Country-mean ICT usage, γ_{0017}		35.44**
Country-mean Parents Emotional Support, γ_{0018}		5.35
Country-mean Sense of Belonging, γ_{0019}		48.37
Country-mean Resilience Self-efficacy, γ_{0020}		-105.90**
Country-mean Mastery Goal Orientation, γ_{0021}		24.23
Country-mean Fear of Failure, γ_{0022}		6.18
Country-mean Occupational Aspiration, γ_{0023}		31.44
Country-mean Belief in the value of school, γ_{0024}		-47.18
Country-mean Growth Mindset, γ_{0025}		26.37
Rural, γ_{010}		-6.92*
City, γ_{020}		5.30
Private School, γ_{030}		2.83
Student-Teacher Ratio, γ_{040}		10.59
Proportion of Fully Certified Teachers, γ_{050}		0.63
Class Size, γ_{060}		0.20
Extra-Curricular Activities in School, γ_{070}		4.27**
Student Behavior Hindering Learning, γ_{080}		-6.65***
Teacher Behavior Hindering Learning, γ_{090}		2.43
School-mean Female, γ_{0100}		2.84
School-mean Parental Education Level, γ_{0110}		0.22
School-mean ICT Usage, γ_{0120}		23.55***
School-mean Parents' Emotional Support, γ_{0130}		18.43***
School-mean Sense of Belonging in School, γ_{0140}		12.92**
School-mean Resilience Self-efficacy, γ_{0150}		-4.03
School-mean Mastery Goal Orientation, γ_{0160}		1.81
School-mean Fear of Failure, γ_{0170}		7.90
School-mean Occupational Aspiration, γ_{0180}		24.11***
School-mean Belief in the value of school, γ_{0190}		9.19
School-mean Growth Mindset, γ_{0200}		23.37***
Female, γ_{100}		-8.69**
Parental Education Level, γ_{200}		-0.12
ICT Usage, γ_{300}		5.49***
Parents' Emotional Support, γ_{400}		3.86***
Sense of Belonging in School, γ_{500}		1.26
Resilience Self-efficacy, γ_{600}		2.45**
Mastery Goal Orientation, γ_{700}		1.32
Fear of Failure, γ_{800}		1.86
Occupational Aspiration, γ_{900}		8.81***
Belief in the value of school, γ_{1000}		1.23
Growth Mindset, γ_{1100}		8.15***

Table 4. Results of HLM Analysis

*Note. *p≤ 0.05; **p≤ 0.01; ***p≤ 0.001*

Model	Country-level Variance		School-level Variance		Student-level Variance	
	Intercept Variance	R^2	Intercept Variance	R^2	Intercept Variance	R^2
Fully unconditional	3382.67***	(Base)	2916.65***	(Base)	4506.93***	(Base)
Conditional	233.93	0.9308	1449.47	0.5030	4315.68	0.0444

Table 5. Proportion of Variance Explained

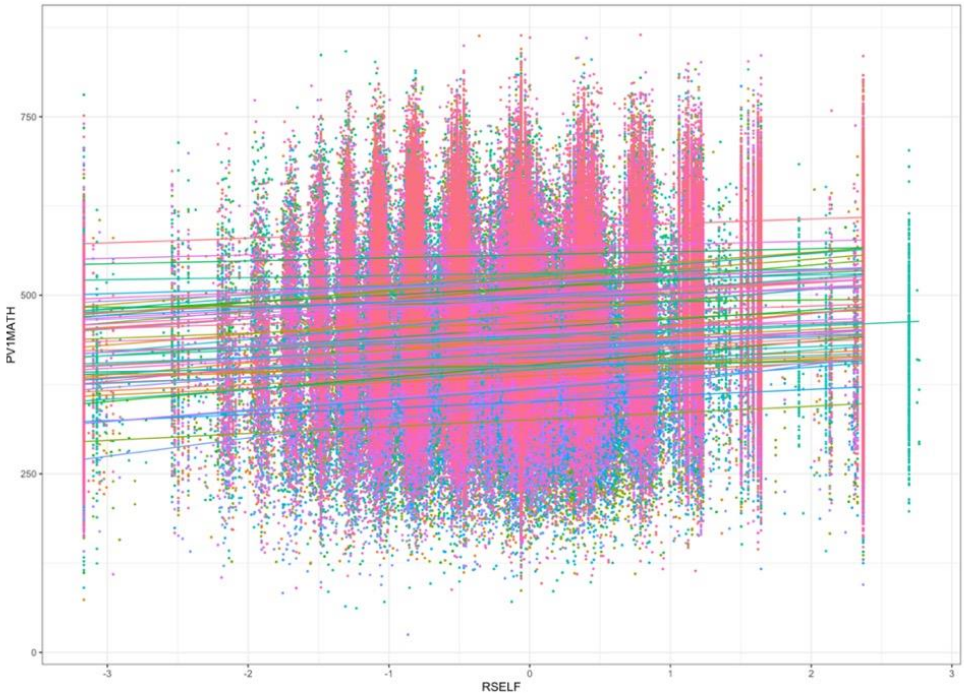

Figure 1. Scatterplot-relationship between resilience self-efficacy (RSEFL)and math achievement (PVMATH)

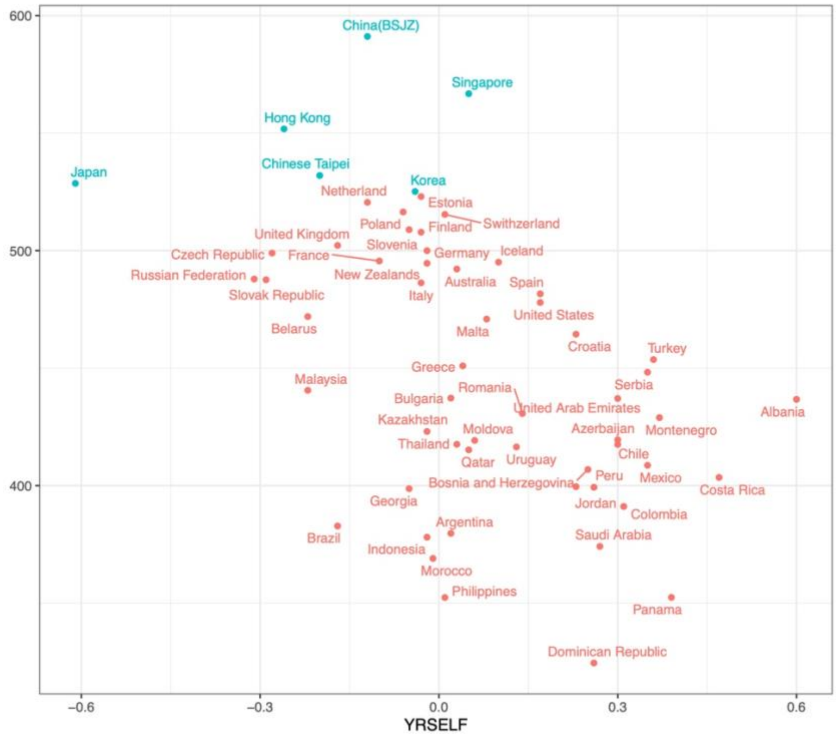

Figure 2. Scatterplot-relationship between country-mean resilience self-efficacy (YRSELF) and country-mean math achievement (YPV1MATH) by grouping East Asian Countries and Not East Asian Countries

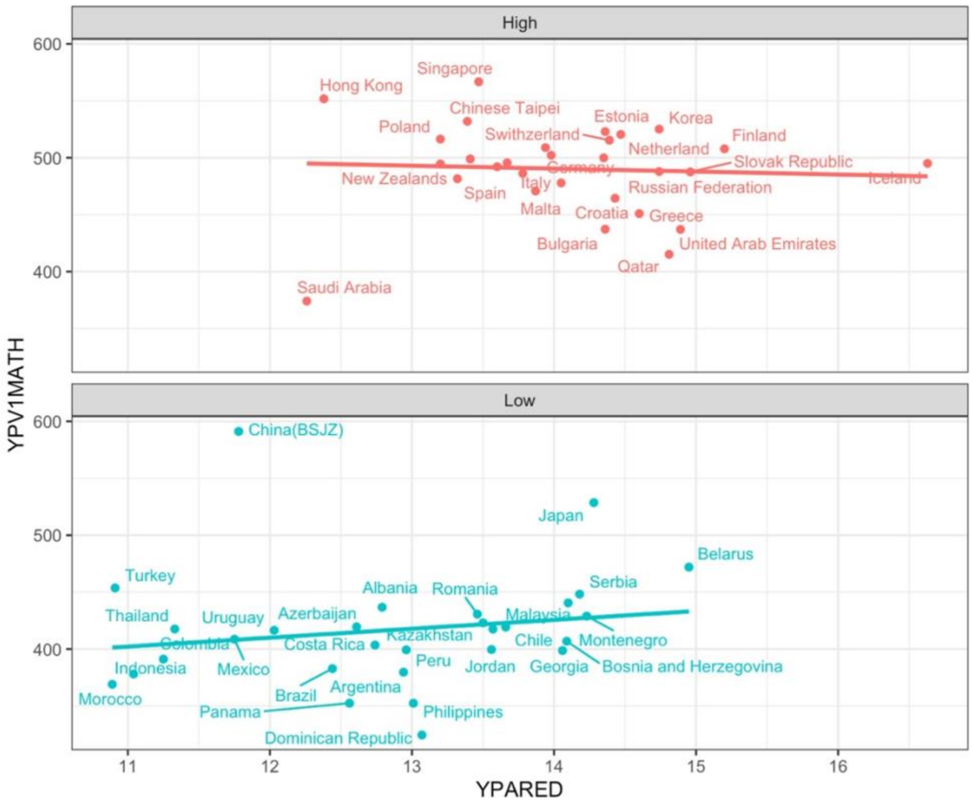

Figure 3. Scatterplot-relationship between country-mean parental education level (YPARED) and country-mean math achievement (YPV1MATH) by grouping ICT usage

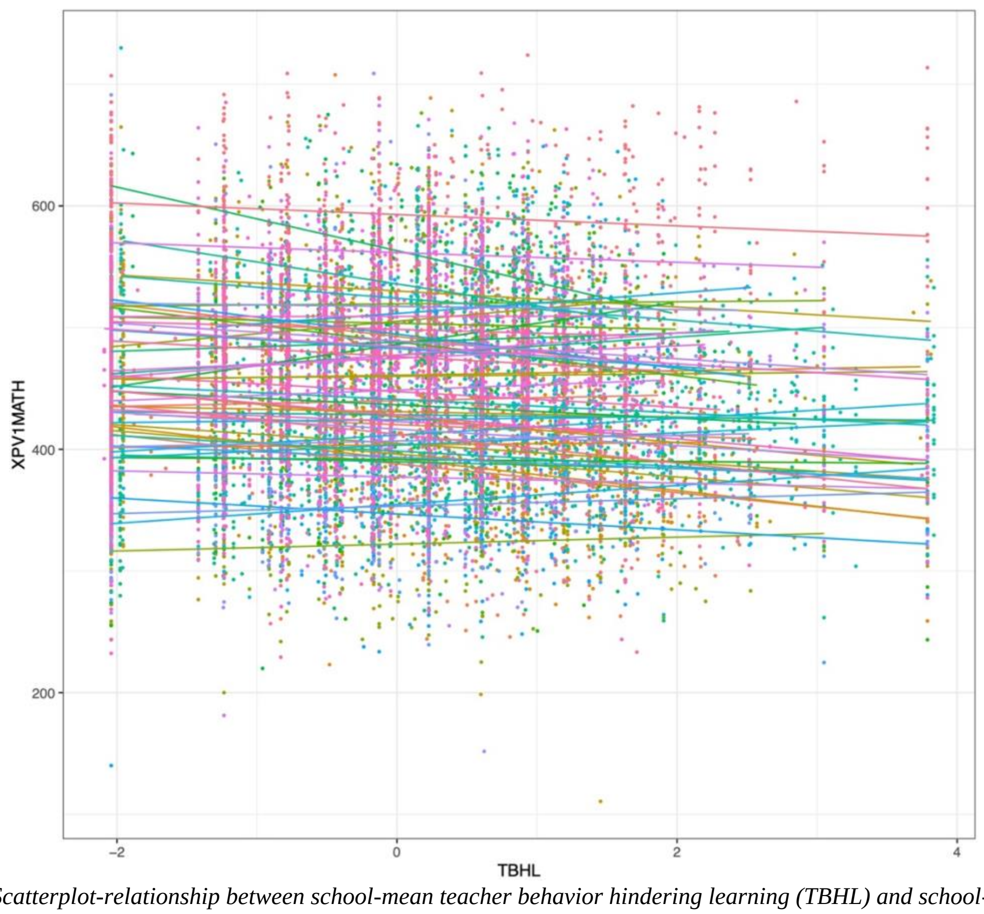

Figure 4. Scatterplot-relationship between school-mean teacher behavior hindering learning (TBHL) and school-mean math achievement (XPV1MATH) by grouping 58 countries

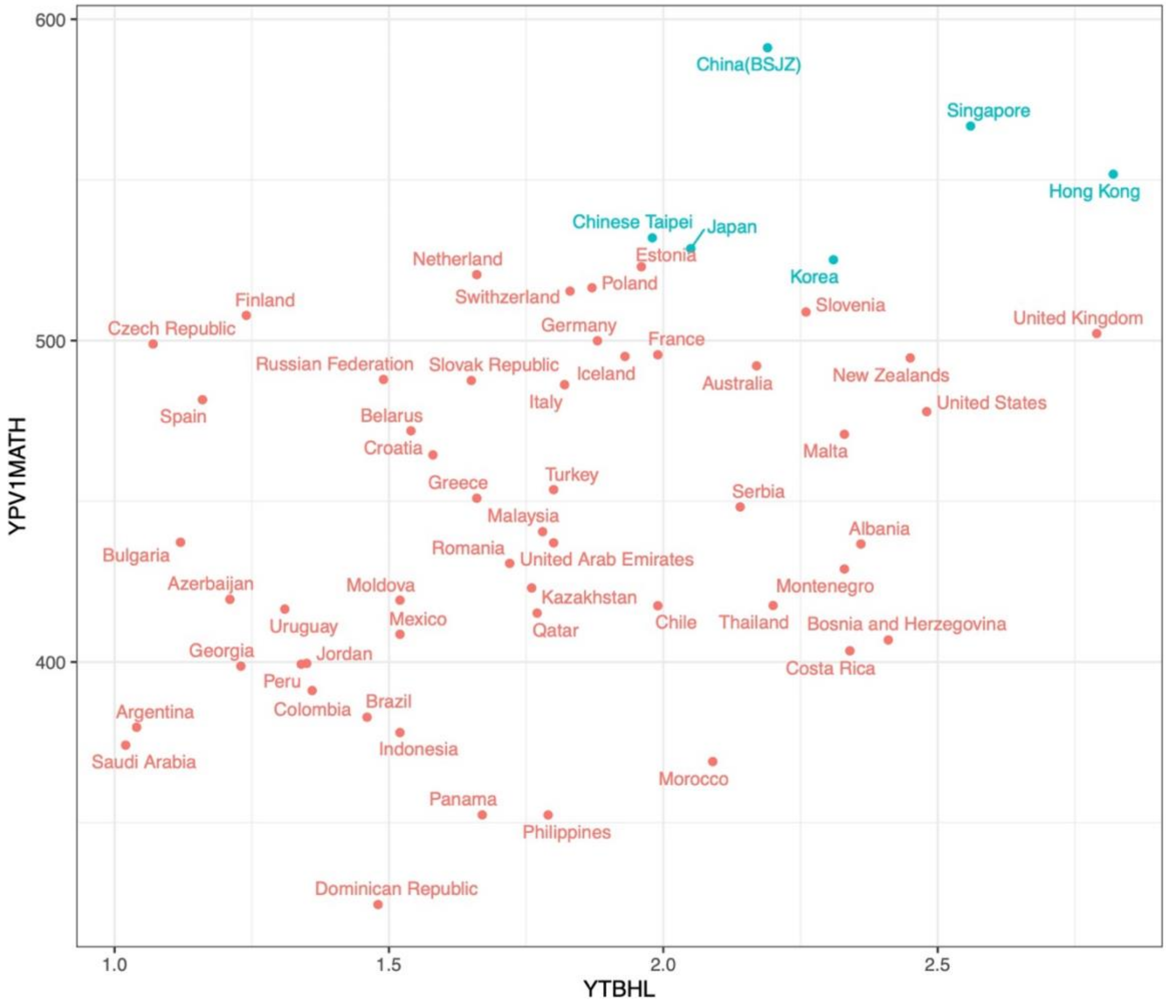

Figure 5. Scatterplot-relationship between country-mean teacher behavior hindering learning (YTBHL) and country-mean math achievement (YPV1MATH) by grouping East Asian Countries and Not East Asian Countries

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