The Relation between Outside of school Factors and Mathematics Achievement: A Cross-country Study among the U.S. and Five Top-performing Asian Countries

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Abstract
Since at least the 1980s, motivated, in part, by findings from international comparisons of students' mathematics achievement, some American (U.S.) educators and policy makers have initiated educational reform that focuses on improving teaching practices and curriculum designs by advocating for the adoption of Asian educational models. The implicit assumption behind such reform seems to overlook the possible roles of outside of school factors in superior academic performance in the Asian countries. The purpose of this study was to investigate how outside of school factors were related to students' TIMSS mathematics achievement for the U.S and five top-performing Asian nations or regions, and to examine whether the relative role of school-associated and outside of school factors was consistent across these five Asian countries. The results indicated that students' achievement was highly related to outside of school factors across all six countries. For Singapore and Hong Kong, school-associated factors had somewhat more salient roles than the outside of school factors. However, for Korea, Taiwan, and Japan, school-associated factors played lessor roles in students' achievement performance. As for the U.S., school-associated factors were related to students' performance, however outside of school factors clearly played more salient roles than the school-associated factors. The findings suggest that students' mathematics achievement covaries substantially with outside of school factors. Hence, students' superior mathematics achievement does not necessarily reflect only a superior public school system but also outside of school factors.

Introduction

Since the 1960s, a series of international comparisons of student achievement have revealed that American (U.S.) students under-performed in mathematics compared to their counterparts in other industrialized countries, East Asian countries in particular (Beaton, et. al., 1996; Mcknight et al., 1987; Robitaille & Garden, 1988; Stevenson et al., 1990). Since the 1980s, a great number of reports have suggested that American mathematics education is at risk and American students have lagged behind their counterparts in many East Asian countries. For example, in 1983, the National Commission on Excellence in Education published *A Nation at Risk*. In 1987, McKnight et. al. published *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective*.

Based, in part, on the findings from the international achievement assessments, such as the Trends in International Mathematics and Science Study (TIMSS), there was a strong call for the reform of the public school system. As a result, many U.S. educators and policy-makers began to undertake educational reform focusing on factors that are controllable by the school systems such as curriculum design, institutional organization, and teaching standards by advocating for the adoption of the educational models of the top-performing Asian countries, (e.g., National Council of Teachers of Mathematics, 1989, 1991, 2000; Interstate New Teachers Assessment and Support Teaching Consortium, 1992). Since the 1980s, the Japanese educational system has been held as a model for the U.S., and in recent years, increasing attention has been paid to the Singaporean model (DeCoker, 2002; Gopinathan, 1997).

There is a tacit and crucial, nonetheless unverified, assumption behind these international comparison-based reforms. That is, it is tacitly assumed that the superior performance of these Asian countries is a planned outcome of the public school systems, instead of that of the outside of school factors. Given that individual, familial, and cultural factors other than the school system have been suggested to play essential roles in Asian students' mathematics achievement, it seems unfounded to attribute Asian students' superior performance in mathematics solely to the public school system. In other words, a disclosure of the integral picture in depicting students' mathematics achievement, in and out of school, would help educators and policy makers reach more effective and realistic decisions. In sum, for the international comparison-based school reforms to be meaningful and useful, it is crucial to understand the potential role that outside of school factors may play in students' mathematics achievement.

Study Purpose

The purpose of this study was to investigate: (1) whether and to what extent the outside of school factors, in the presence of school-associated factors, were related to students' mathematics achievement for the U.S. and five top-performing Asian nations/regions (i.e., Korea, Taiwan, Japan, Singapore, and Hong Kong); (2) whether the relative role of school-associated and outside of school factors is consistent across these five top-performing countries. We will first briefly review literature on the relation of both in and out of school factors related to mathematics achievement and then present the findings of the present study addressing these factors with TIMSS 2003 data.

School-Associated Factors Related to Mathematics Achievement

In terms of curriculum, a large amount of research has explored the differences in mathematics curriculum between the U.S. and some top-performing Asian countries. Substantial differences have been found in their curricula. Silver (1998) nicely summarizes this review by stating that the mathematics curriculum in the U.S. is a mile wide and an inch deep. Many researchers indicated that institutional organization has an impact on achievement (Greenwald, Hedges, & Laine, 1996; Lee & Bryk, 1989). TIMSS researchers have noted that, in the U.S., grade 8 students of different abilities are typically grouped into different classrooms and study different materials, whereas no such ability grouping is commonly adopted in East Asian countries (Lee, 1998; Silver, 1998). School size and classroom size are other factors related to students' access to learning. Lee, Smith, and Croninger (1997) have found that larger schools negatively affect students' mathematics and science performance. However, using TIMSS data, other researchers have found that larger class size is positively associated with students' superior performance in mathematics for top-performing Asian countries (Silver, 1998).

Other reform has focused on teaching quality that may have influenced the U.S. students' performance in mathematics. Substantial differences have been found in instructional practices in the classroom. American teachers have often emphasized skill acquisition that leads to lower-level cognitive processes, whereas Asian teachers have always assisted students in obtaining deeper understanding, which leads students to engage in constructive thinking processes (Lee, 1998; Silver, 1998). Stigler and Perry (1988) reported that Chinese teachers spent substantially more time on classroom instruction than did the U.S. teachers. In addition, some researchers advocated the whole-class teaching method implemented by Asian teachers and suggested that the practice of reducing class size in America was not helpful to improve teaching-learning quality (Stevenson & Lee, 1995; Stigler & Perry, 1988; Wang & Lin, 2005). Furthermore, TIMSS findings have shown that American teachers have less structured support for their professional development (Silver, 1998). Chinese and Japanese teachers were organized to take part in professional activities, such as observing and critiquing each other's teaching. However, American teachers had little chance to interact with their colleagues and were more likely to work in isolation (Lewis, 2000; Paine, 1997; Paine & Ma, 1993).

Outside of school Factors Related to Mathematics Achievement

Many researchers have explored whether factors other than school-associated factors have an influence on students' performance. Family characteristics (e.g., parents' education and parents' values) have been suggested to have a direct influence on students' school performance (Steinberg, Elmen, & Mounts, 1989). Parents' education level and their expectations have been demonstrated to be positively associated with students' performance (Blair & Qian, 1998; Schreiber, 2000). Also, students' attitudes and beliefs played an important role in their mathematics achievement (McLeod, 1992). Many researchers have found that positive attitudes are likely to lead to higher achievement, and positive self-concepts lead to higher motivation and thus to higher learning outcomes (e.g., Ma, 1997; Maslow, 1971; Rogers, 1982). However, some researchers have suggested that attitude and self-concept are ineffective predictors of students' mathematics achievement based on their findings that high performing Asian students have lower self-concept and more negative attitudes than their U.S. counterparts. (Howie et al., 2000; Lokan & Greenwood, 2000; Shen & Pedulla, 2000; Shen, 2002; Papanastasiou, 2002). In addition to family and students' personal factors, private tutoring has been pervasive in Japan, Korea and Taiwan, and has been shown to have a positive effect on student achievement (Bender, 1994; Invernizzi, Juel, & Rosemary, 1997; Lee, 1998). Some researchers have even argued that the pervasive private tutoring is a result of poor public education in these countries (Koskinen & Wilson, 1982; Goya, 1994; Johnson & Johnson, 1996).

Method

Participants

Three types of participants were involved in this study: students, the students' teachers, and the students' school principals. The student participants were grade-8 equivalent (approximately 13 years old) students at the time of testing in each country. Student sample sizes were: 8,912 (U.S.), 5,309 (Korea), 4,856 (Japan), 5,379 (Taiwan), 6,018 (Singapore), and 4,972 (Hong Kong). The number of students within each school ranged from 20 to 60 for Korea, 8 to 43 for Japan, 19 to 55 for Taiwan, 4 to 63 for U.S., 27 to 43 for Singapore, and 23 to 188 for Hong Kong. Data from one Japanese and five U. S. schools were removed because those schools had less than 10 students. The final numbers of principals (which is the same as the number of schools) were: 150 (Korea), 146 (Japan), 151 (Taiwan), 165 (Singapore), 126 (Hong Kong), and 297 (U.S.). Excluding missing data and teachers who had less then 10 students, the final teacher sample sizes were: 256 (Korea), 145 (Japan), 150 (Taiwan), 322 (Singapore), 135 (Hong Kong), and 330 (U.S.).

Instrument and Variables

TIMSS 2003 grade-8 mathematics tests were used as our mathematics achievement measure. The outcome variable for mathematics achievement was the average of five plausible values. Although individual students took a test that had some different items from those taken by the other students as a result of the matrix sampling, plausible values estimated by item response theory scaled students' performance on a common metric with a mean of 500 and standard deviation of 100, and hence, made cross-student and cross-country comparisons possible.

Along with the TIMSS achievement test administration, comprehensive background questionnaires were administered to the students, students' teachers, and the school principals. The student's questionnaire asked about their home backgrounds, their attitudes toward learning mathematics, and their experiences in learning mathematics. The teacher's questionnaire asked teachers about their teaching preparation, teaching activities and approaches, attitudes toward teaching, as well as the curriculum covered in the classroom.

The principal's questionnaire asked school principals to provide information about curricular and instructional arrangements, school resources, and school climate. These questionnaires were used in the present study to identify potential school-associated variables and outside of school variables that are related to the students' achievement. As a result of our literature review and empirical correlation analyses on TIMSS data, a set of variables was selected to study their relationships with mathematics achievement. These variables included items in the questionnaires originally answered by the participants as well as "indices" and "derived variables" reproduced by TIMSS (See Supplement 3, TIMSS 2003 User-guide). The selected variables were classified into school-associated variables and outside of school variables.

It is crucial to note that our categorization of school-associated and outside of school factors was based on the TIMSS data collection design. That is, school-associated variables refer to variables collected from the teacher's and principal's questionnaires, and outside of school variables refer to variables collected from the student's questionnaire. The outside of school factors are comprised of individual, familial, and cultural factors. The school-associated factors included *school context* factors, such as school climate, and *school practice* factors, such as curriculum coverage (Raudenbush & Willms, 1995).

As a result of our classification, eight outside of school variables reflecting students' individual, familial, and cultural differences were included in our study. The school-associated variables included: seven principal variables from the principals' report on schools' contexts and practices, and twenty-four teacher variables from the teachers' report on teaching practices in the classroom and professional development. All of the variables, including school-associated and outside of school, are listed and described in Table 1.

Data Analyses

Two classes of statistical methods were adopted to answer our research questions. Method-1 utilized hierarchical linear modeling (HLM) (Raudenbush & Bryk, 2002). Method-2 utilized a variable ordering technique, the relative Pratt index (Pratt, 1987; Thomas, Hughes, & Zumbo, 1998; Thomas & Zumbo, 1996), used in multiple regression analyses. The TIMSS data were structured as follows: students were nested within teachers, and teachers were nested in schools and hence, students with the same

Table 1
Description of Variables Used in HLM Analyses

Variables	Code or range	Description
Student-level Variables		
Outcome variable		The average of five plausible values of mathematics.
Parent educational level (PARENTEDU)	1 - 5	A variable derived from students' responses to the highest education level of both mother and father (1 = no more than primary schooling, 2 = finish lower secondary schooling, 3 = finish upper secondary schooling, 4 = finish post-secondary vocational/technical education, 5 = finish univ. or higher).
Educational aspirations (ASP)	1 - 4	A variable derived from students' responses to how far in school they expect to go relative to parents' educational level (1 = do not know regardless of parents' education, 2 = not finish univ. regardless of parents' education, 3 = finish univ. but neither parent went to univ., 4 = finish univ. and either parent went to univ.).
Students' self-confidence in learning mathematics (SLCONF)	1 - 3	An index shows students' self-confidence in learning mathematics and is derived from student's responses to four questions regarding mathematics: (a) I usually do well in math, (b) math is more difficult for me than for many of my classmates, (c) math is not one of my strengths, and (d) I learn things quickly in math. (1 = low, 2 = medium, 3 = high).
Students' valuing mathematics (VALUE)	1 - 3	An index shows students valuing the importance of math, which is derived from seven questions. (1 = low, 2 = Medium, 3 = high).
Time students spend doing math homework (TIMHW)	1 - 3	A variable is derived from 2 questions: (a) how often your teacher gives you homework in math, and (b) when your teacher gives you math homework and how many minutes are you usually given. (1 = low, 2 = medium, 3 = high).
Extra lessons or tutoring (TUTORING)	1 - 4	An original variable from student questionnaire to indicate the frequency of extra lessons or tutoring in mathematics (1 = never, 2 = sometimes, 3 = once or twice a day, 4 = every day).
Availability of computer (AVABLCOMP)	1 - 5	A derived variable from two questions: (a) Do you ever use a computer, and (b) Where do you use a computer (1 = Do not use at all, 2 = only at places other than home and school, 3 = at school but not at home, 4 = at home but not at school, 5 = both at home and school).
Number of books at home (NRBOOK)	1 - 5	(1 = 0 - 10, 2 = 11 - 25, 3 = 26 - 100, 4 = 101 - 200, 5 = more than 200).

School-level Variables		
<u>*Principal variables*</u>		
School size (SCHSIZE)		The enrollment of total students in the school.
Good school and class attendance (GOODSCH)	1 - 3	A composite index based on (a) how often the following problem behaviors occur in the school, such as arriving late, absenteeism, skipping class, classroom disturbance, cheating, profanity, and vandalism and (b) if the behavior occurs, how severe a problem does it present (1 = low, 2 = medium, 3 = high).
School climate (SCHCLIMATE)	1 - 3	A composite index based on principles' response to eight questions regarding school climate, including teachers' job satisfaction, understanding of the school's curricular goals, degree of success in implementing the school's curriculum, and expectations for student achievement, and involving parental support and students' regard for school property (1 = low, 2 = medium, 3 = high).
Low social economic status (LOWSES)	1 - 4	Percentage of students in the school who come from economically disadvantage home (1 = 0 - 10%, 2 = 11 - 25%, 3 = 26 - 50%, 4 = more than 50%).
High social economic status (HIGHSES)	1 - 4	Percentage of students in the school who come from economically affluent home (1 = 0 - 10%, 2 = 11 - 25%, 3 = 26 - 50%, 4 = more than 50%).
Grouping instruction (GROUPCURRICULUM)	1 - 3	Organization of curriculum for grade 8 students with different levels of ability (1 = study same curriculum, 2 = same curriculum, but at different levels of difficulty, 3 = different math curricula according to their ability).
Grouping students (GROUPSTUD)	0 = No, 1 = Yes	Grouping students within their math classes by their levels of ability.
<u>*Teacher variables*</u>		
Perception of no or few limitations on instruction due to students (PERCPLIMIT)	1 - 3	An index of teachers' reports on teaching math classes with few or no limitations on instruction due to student factors (i.e., students with different academic abilities, from a wide range of backgrounds, with special needs, uninterested student, etc.) 1 = a lot of limitation, 2 = some limitation, 3 = no limitation or little).
Emphasis on homework (EMHW)	1 - 3	This index is computed from two items: (a) do you assign math homework to the TIMSS class, (b) how many minutes do you usually assign (3 = high, 2 = medium, 1 = low).
Class size (CLASIZE)	1 - 4	The number of student in TIMSS classes (1 = 1 - 24, 2 = 25 - 32, 3 = 33 - 40, 4 = above 41).
Covering overall math topics (MATHTOPICS)	1 - 3	This index describes when TIMSS class students have been taught over topics of number, geometry, algebra, data, and measurement (percentage of overall math topics covered) (1 = not yet taught or just introduced, 2 = most taught this year, 3 = mostly taught before this year).

Teaching time (TCHTIME)		This item indicates how many minutes per week the teachers teach math to the TIMSS class.
Interaction with colleagues (INTERACTION)	1 - 4	Four individual items describe how often teachers have four types of interactions with other teachers (1 = never, 2 = 2 or 3 times/month, 3 = 1 - 3 times/week, 4 = daily or almost daily).
Professional development (PROFDEVELOP)	0 = No, 1 = Yes	Six individual items indicate whether teachers have participated in various types of professional development in the past two years.
Content related activities (CONTENTACT)	1 - 4	Nine individual items indicate the frequency with which the teacher asks students to do various content-related activities in math (1 = never, 2 = some lessons, 3 = about half the lessons, 4 = every lesson).

teachers and the same school were more likely to share the same context than students from different teachers or schools. In this sense, the clustered data may violate the assumption of independence of all observations found in ordinary least-squares regression. Therefore, HLM analyses were utilized to deal with the clustered data. The second method, the relative Pratt index, allowed us to investigate school and outside of school effects using a single model including all factors. However, both statistical procedures had their own advantages as well as limitations, which are described below.

Method-1. For TIMSS data, which was clustered by data collection design, HLM analyses had the advantage of increasing the precision of the coefficient estimates of school level variables and the power of hypothesis tests of the coefficients by controlling for the variation in student level variables. This advantage is especially the case if the student level factors were strongly related to the outcome variable (Lee & Bryk, 1989; Bachmann & Hornung, 2003). The amount of dependence of observations can be expressed as the intraclass correlation, which can be estimated in the unconditional multilevel model -- that is, the model only with intercept and residual error term. The absence of intraclass correlation indicates that there is no design effect caused by clustered data. However, Kreft and de Leeuw (1998) have indicated that even a small intraclass correlation of .01 can substantially inflate the Type I error. Hence, the intraclass correlation was reported in the section of results to indicate the necessity of using HLM technique for the present study.

For the TIMSS data collection design, students (level-1) were nested within teachers (level-2) and teachers were nested in the schools (level-3), which normally involves a 3-level HLM to appropriately account for the variation of the nested data. However, a 3-level model was not adopted for this study because of the insufficient teacher sample size at level-2 (i.e., only one or two teachers were nested in each school). An intuitive way to remedy this problem was to aggregate the scores for the teacher variables to the school level by taking the average of the teachers. However, considering that scores based on one teacher or the average of the two teachers were not representative of the school, this approach was not adopted. Instead, two 2-level analyses were modeled: (1) *Student-teacher Model*, which involved the estimation of variation between students' mathematics achievement nested within teachers, and (2) *Student-principal Model*, which involved the estimation of variation between students' mathematics achievement nested in the schools. The structure of these 2-level models is presented in Figure 1.

Figure 1
The Structure of Two 2-level Hierarchical Linear Models

Student-principal Model

	Model A	Model B	Model C
Level 1	None	Outside-of-school Variables	Outside-of-school Variables
Level 2	None	None	School-associated Variables

Student-teacher Model

	Model A	Model B	Model C
Level 1	None	Outside-of-school Variables	Outside-of-school Variables
Level 2	None	None	School-associated Variables

The linearity assumption on the level-1 outcome variable was examined and shown to be appropriate for our data. Following the suggestions by Raudenbush and Bryk (2002), all predictors at level-1 were centered about their means for ease of interpretation. For parameter estimation, "restricted maximum likelihood" (RML) method was used. The various models will be introduced later in the results section.

Method-2. To remedy the inability to incorporate both teacher and principal variables in one HLM model in method-1, a multiple regression analysis was conducted and then the Relative Pratt indices (Thomas, Hughes, & Zumbo, 1998) were calculated to order the relative importance of outside of school and school-associated variables. Using criteria described by Thomas et al. as well as Thomas and Zumbo (1996), variables that accounted for R-squared > 0.02 were regarded as important variables; this is a conservative implementation of Thomas et al.'s criteria for importance, $1/2p$ where p is the number of predictors in the regression model. The limitation of the multiple regression approach was that the test of statistical significance for the regression parameters (and the overall model) would be inflated due to the design effect, the intraclass correlation. It should be noted, however, that the Pratt indices are descriptive and do not involve statistical significance, so the design effect problem is less worrisome for investigating the relative importance of variables.

Results

The descriptive statistics of the outcome variables (TIMSS 2003 mathematics score) are reported in Table 2. Reporting of the Asian countries was ordered by TIMSS international rankings (from top one to top five) across 46 participating countries. The U.S. students' score was slightly above the international average and was ranked as 14th place.

Statistical Method-1: Hierarchical Linear Modeling

In the next paragraphs, three HLM models are presented to investigate the relationships of in and out of school factors to students' mathematics achievement – referred to as Model-A, Model-B, and Model-C throughout. Because effects of school-associated factors were investigated separately by teacher and principal variables, each of Models A-C school effects were examined by two separate 2-level models: model for students nested within

Table 2
Descriptive Statistics of TIMSS Grade-8 Students' Mathematics Achievement

Nations	*N*	Mean	SD	Min.	Max.
SGP	6018	602	77	349	804
KOR	5379	589	81	281	846
HK	4972	588	68	291	752
TWN	5379	587	97	265	831
JPN	4856	569	77	274	833
US	8912	504	78	263	738

teachers (i.e., student-teacher model) as well as model for students nested in schools (i.e., student-principal model).

Unconditional Model (Model-A)

The 2-level unconditional model served to partition the total variance in mathematics achievement into within school (i.e., the effect of outside of school variables) and between school (i.e., the effect of school-associated variables) components. The unconditional model included a random intercept β_{0j} and a level-1 residual r_{ij}. The level-1 model was specified as:

$$\mathrm{Y}_{ij} = \beta_{0j} + r_{ij},$$

where *i* denotes individual students and *j* denotes schools, and the random intercept of level-1 was the outcome of the level-2 model,

$$\beta_{0j} = \gamma_{00} + u_{0j},$$

where γ_{00} was the grand mean of mathematics scores for the school-level distribution and u_{0j} was the variation between schools. This model is equivalent to a one-way ANOVA with random effects.

The results of the unconditional model were presented in Table 3. In terms of the student-principal model, the estimated average mathematics scores across schools were 588.2, 567.9, 584.7, 502.2, 601.7, and 584.1 for Korea, Japan, Taiwan, U.S., Singapore, and Hong Kong, respectively. Both student-level and school-level residual variances were statistically significant, suggesting that there was a need to add predictors to account for the left-over variances at both levels. The comparisons of the intraclass correlations across six countries indicated that substantial proportions of variance in average mathematics achievement could be accounted for by school-level variables for U.S., Singapore, and Hong Kong (i.e., 0.43, 0.41, and 0.62). However, for Korea, Japan, and Taiwan, less proportions of variance in average mathematics achievement can be accounted for by school-level variables indicated by the relatively lower intraclass correlations, (i.e., 0.10, 0.15, and 0.30). The results of the student-teacher model showed similar patterns as the student-principal model except for slight differences in the parameter estimates.

Table 3

Multilevel Estimates for Unconditional Model (Model-A)

Parameter		Coefficient					
		KOR	**JPN**	**TWN**	**U.S.**	**SGP**	**HK**
Student-principal Model							
Fix effect							
Intercept	γ_{00}	588.2***	567.9***	584.7***	502.2***	601.7***	584.1***
Random effect							
Level-1 variance	σ_{ε}^{2}	5976***	4941***	6569***	3455***	3478***	1906***
Leve-2 variance	σ_{u0}^{2}	627***	875***	2872***	2568***	2420***	3111***
Intraclass correlation		0.1	0.15	0.3	0.43	0.41	0.62
Goodness-of-fit	Deviance	62266	55358	62961	98669	66682	52178
Student-teacher Model							
Fix effect							
Intercept	γ_{00}	590.3***	567.9***	584.2***	500.7***	599.5***	580.0***
Random effect							
Level-1 variance	σ_{ε}^{2}	5945***	4941***	6542***	2535***	1322***	1864***
Leve-2 variance	$\sigma_{\mu0}^{2}$	626***	875***	2930***	3856***	4716***	3483***
Intraclass correlation		0.1	0.15	0.31	0.6	0.78	0.65
Goodness-of-fit	Deviance	62322	55358	62946	96453	61633	52137

Note: *** denotes α significance level at .001, ** at .01, * at .05.

Outside-school-effects-only Model (Model-B)

In the second stage, we began to test the relationship between the eight outside of school factors and students' mathematics achievement. The random intercept and slope model, which is also called a random-coefficient regression model by Raudenbush and Bryk (2002), was adopted because the slopes of level-1 variables were hypothesized to vary across schools. Thus, the central concern in Model B was to test if the slopes of level-1 factors were random across schools for each of the six countries. If the slopes of level-1 variables were not varying across schools, then they should be fixed. For Model-B, level-1 and level-2 models were specified as:

$$Y_{ij} = \beta_{0j} + \beta_{1j}\text{PARENTEDU} + \beta_{2j}\ \text{ASP} + \beta_{3j}\ \text{VALUE} + \beta_{4j}\ \text{SLCONF}$$
$$+ \beta_{5j}\ \text{TMHW} + \beta_{6j}\ \text{TUTORING} + \beta_{7j}\text{AVABLCOMP} + \beta_{8j}\text{NRBOOK} + r_{ij},$$
$$\beta_{0j} = \gamma_{00} + u_{0j},$$
$$\ldots$$
$$\beta_{Pj} = \gamma_{P0} + u_{Pj}\ \ (p = 1, 2, \ldots, 8).$$

The results of Model-B analyses showed that for some countries, allowing the level-1 slopes variant across schools were mis-specified and failed to achieve convergence. Therefore, there was a need to fix some non-significant variances and all covariances of level-1 factors. The final results of partly-fixed-partly-random level-1 slope model are presented in Table 4.

In terms of the student-principal model, the slope of all eight level-1 variables were fixed for Japan, and nearly all of them were fixed for Korea, Taiwan, and Hong Kong. This indicated that there was no cross-school variation in the relationships between all outside of school factors and mathematics achievement for Japan. Cross-school variation in the achievement and predictor relationship only existed in parents' education (PARENTEDU) and students' valuing the importance of mathematics (VALUE) for Korea, only in students' aspiration relative to parents' education (ASP) and tutoring time in mathematics (TUTORING) for Taiwan, only in students' self-confidence in learning mathematics (SLCONF) and time spending on mathematics homework (TMHW) for Hong Kong. On the contrary, the slopes of level-1 variables were mostly random for U.S. and Singapore. The varying slopes of student-level variables in U.S. and Singapore indicated that outside of school variables varied across schools.

In terms of the student-teacher model, the relationship between mathematics and the eight outside of school factors were consistent with the findings of the student-principal model for Japan. For Korea and Taiwan, only the relationships between mathematics achievement and ASP varied

Table 4

Multilevel Estimates for Model-B

	Parameter	Coefficient Estimates					
Student-principal Model		**KOR**	**JPN**	**TWN**	**U.S.**	**SGP**	**HK**
Fix effect							
Intercept	γ_{00}	587.8***	567.3***	591.9***	469.4***	602.9***	575.2***
PARENTEDU	γ_{10}	***0.8***	5.9***	2.2*	2.8***	***0.8***	***-1.0***
ASP	γ_{20}	12.0***	13.4***	17.2***	5.8*	6.3***	***0.3***
VALUE	γ_{30}	10.1***	5.3***	6.8***	-2.7***	8.3***	6.0***
SLCONF	γ_{40}	40.3***	35.0***	43.4***	27.4***	22.2***	24.4***
TMHW	γ_{50}	-2.9*	-10.4***	4.2**	9.1***	12.5***	***0.9***
TUTORING	γ_{60}	-4.2***	3.3**	-5.8***	18.3***	3.1*	7.7***
AVABLCOMP	γ_{70}	12.2***	7.7***	9.9***	5.9***	10.0***	4.4***
NRBOOK	γ_{80}	12.0***	7.6***	11.2***	8.4***	6.4***	1.7***
Random effect	Variance Component						
Level-1 variance	σ_{ε}^{2}	3164***	3044***	3686***	2185***	2171***	1320***
Leve-2 variance	σ_{u0}^{2}	254***	622***	1191***	1356***	1318***	2562***
PARENTEDU	σ_{u1}^{2}	38.3*	-	-	-	73.1***	-
ASP	σ_{u2}^{2}	-	-	101.5***	42.8***	140***	-
VALUE	σ_{u3}^{2}	73.8*	-	-	52.6*	74.1**	-
SLCONF	σ_{u4}^{2}	-	-	-	61.8***	251.3**	35.3*
TMHW	σ_{u5}^{2}	-	-	-	262.5***	144***	40***
TUTORING	σ_{u6}^{2}	-	-	36.9*	27.1**	-	-
AVABLCOMP	σ_{u7}^{2}	-	-	-	-	-	-
NRBOOK	σ_{u8}^{2}	-	-	-	-	39***	-
Goodness-of-fit	Deviance	54361	37259	55560	73186	53006	43144
Student-teacher Model		**KOR**	**JPN**	**TWN**	**U.S.**	**SGP**	**HK**
Fix effect							
Intercept	γ_{00}	588.6***	567.3***	591.4***	472.6***	597.1***	571.7***
PARENTEDU	γ_{10}	***0.8***	5.9***	2.1*	2.2***	***-0.3***	***-1.0***
ASP	γ_{20}	12.5***	13.4***	17.2***	3.6***	***-0.1***	***0.6***
VALUE	γ_{30}	10.3***	5.3***	6.8***	***-1.7***	8.1***	5.8***
SLCONF	γ_{40}	40.2***	35***	43.6***	24.4***	18.4***	24.3***
TMHW	γ_{50}	***-2.3***	-10.4***	4.4**	***2.1***	1.9*	***1.2***
TUTORING	γ_{60}	-4.2***	3.3**	-5.6***	15.7***	3.4***	7.6***
AVABLCOMP	γ_{70}	11.5***	7.7***	9.9***	4.2***	4.5***	4.3***

NRBOOK	γ_{80}	12.2***	7.6***	11.3***	6.7***	0.9*	1.6***
Random effect							
Level-1 variance	σ_{ε}^{2}	3172***	3044***	3718***	1686***	918***	1274***
Leve-2 variance	σ_{u0}^{2}	264***	622***	1241***	2328***	4064***	2842***
PARENTEDU	σ_{u1}^{2}	-	-	-	-	-	-
ASP	σ_{u2}^{2}	54.3*	-	101.6***	19.0*	-	40.2*
VALUE	σ_{u3}^{2}	-	-	-	39.3*	39.5*	-
SLCONF	σ_{u4}^{2}	-	-	-	32.3**	-	39.0**
TMHW	σ_{u5}^{2}	-	-	-	122.7	32.2*	46.3*
TUTORING	σ_{u6}^{2}	-	-	-	26.3**	66.9***	-
AVABLCOMP	σ_{u7}^{2}	-	-	-	32.0*	-	-
NRBOOK	σ_{u8}^{2}	-	-	-	14.5**	-	-
Goodness-of-fit	Deviance	54404	37259	55564	71941	49278	43127

Note: *** denotes α significance level at .001, ** at .01, * at .05.

across classrooms. However, the relationships between mathematics and all the outside of school factors varied across classrooms for U.S., Singapore, and Hong Kong. As a result of the above procedures for fixing the non-random effects, Model-B converged for all six countries, both student-principal and student-teacher models.

The results of Model-B showed that most of the outside of school variables were statistically significantly and positively related to students' performance except that a few variables had a negative relationship with the outcome variable for some countries, such as time spending on mathematics homework in the student-principal model (–2.9 for Korea and –10.4 for Japan). Students' self-confidence in mathematics ability (SLCONF), tutoring time in mathematics (TUTORING), availability of computer (AVABLCOMP), and the number of books at home (NRBOOK) were found to be significant positive indicators for both student-principal and student-teacher models. A few outside of school variables were not statistically significant for some countries. For example, parent educational level was not a significant predictor for Korea (0.8), Singapore (-0.3), and Hong Kong (-1.0) in the student-principal model. Although some outside of school variables were shown non-significant for some countries, they were kept in the model in the next stage for the purpose of cross-country comparisons. Therefore, all the outside of school variables were used in the next model – "school-effect model".

School-effects Model (Model-C)

To investigate whether school-associated factors were still significantly related to mathematics achievement after controlling for outside of school factors, the school-effects models were examined by adding school-level variables to explain the variation in the intercepts at level-2. Level-1 and level-2 models were specified as:

$$Y_{ij} = \beta_{0j} + \beta_{1j}\text{PARENTEDU} + \beta_{2j}\text{ ASP} + \beta_{3j}\text{ VALUE} + \beta_{4j}\text{ SLCONF}$$

$$+ \beta_{5j}\text{ TMHW } + \beta_{6j}\text{ TUTORING} + \beta_{7j}\text{AVABLCOMP} + \beta_{8j}\text{NRBOOK} + r_{ij},$$

$\beta_{0j} = \gamma_{00} + \gamma_{0k}\, w_k + \mu_{0j}$, (k = 1, 2, … 7 for Student-principal Model; k = 1, 2, …, 24 for Student-teacher Model), $\beta_{Pj} = \gamma_{P0} + u_{Pj}$ or $\beta_{Pj} = \gamma_{P0}$ (p =1, 2, …, 8 & some of u_{Pj} were fixed zero, see Table 4) where w_k denotes variables.

The results of Model-C with parameter estimates are provided in Tables 1A (student-principal model) and 2A (student-teacher model) in the Appendix. The results of school and outside of school factor effects (Model-C) were summarized in Table 5 (student-principal model) and Table 6 (student-teacher model). In the summary tables, we only presented the results of hypothesis tests and the direction of the relationships, because our purpose was to find the significant factors, school or outside of school factors, which are common and/or inconsistent across the six countries.

Effects of outside of school variables. The results indicated that outside of school factors were substantially related to students' achievement for Korea, Japan, Taiwan, and U.S., but were relatively less related for Singapore and Hong Kong. In addition, the results showed that after including school-level variables, a few of student-level variables were no longer associated with mathematics achievement, such as parental education levels (PARENTEDU) for Taiwan in both student-principal and student-teacher models, and time spent doing mathematics homework (TMHW) for Singapore in the student-teacher model.

Despite that, most parameter estimates for the student-level variables were still statistically significant for Korea, Japan, Taiwan, and U.S. when compared to Model-B results. In both student-principal and student-teacher models, students' self-confidence in learning mathematics (SLCONF) was positively related to mathematics achievement across all six nations. Student's valuing the importance of mathematics (VALUE) was a positive indicator of mathematics achievement for all five Asian nations, but was negatively related to mathematics achievement for the U.S. in the student-principal model and was not a significant indicator for U.S. in the student-teacher model. Tutoring time (TUTORING) was positively related to achievement for Japan, U.S., Singapore, and Hong Kong, but negatively related to achievement for Korea and Taiwan. In addition, the availability of computers at school and home (AVABLCOMP) was a positive indicator across six nations in the student-principal model.

Effects of school-level variables (Student-principal Model). The results showed that none of the school-associated variables were related to students' achievement for Japan, however, various number of school-associated variables were related to mathematics achievement for other countries. The findings displayed somewhat different patterns from that found in the literature. The percentage of students from low social class (LOWSES) was related to students' achievement for Korea, Taiwan, and U.S., but was not related to achievement for Japan, Singapore, and Hong Kong. Good school and class attendance (GOODSCH) was positively related to mathematics achievement only for U.S. and Hong Kong, but unrelated to achievement for other countries. Grouping students in their mathematics class by their ability (GROUPSTUD) was not related to mathematics achievement for all nations. Organization of curriculum for students with different levels of ability (GROUPCURRICULU) was not related to mathematics achievement for all countries except Hong Kong in which it was negative related to achievement. Note that there was no value for Singapore on GROUPCURRICULUM, because all Singapore teachers indicated that they used different curriculum for their students. School size (SCHSIZE) was positively related to achievement only for Korea, Singapore and Hong Kong.

Effects of school-level variables (Student-teacher Model). In terms of teacher variables, Table 6 shows that most of them were not associated with mathematics achievement across six nations, but compared to Korea, Japan, and Taiwan, more teacher variables were related to achievement for U.S., Singapore, and Hong Kong. Teacher's emphasis on mathematics homework (EMHW) and coverage of mathematics topics (MATHTOPICS) were positive related to achievement for U.S., Singapore, and Hong Kong, but unrelated to achievement for Korea, Japan, and Taiwan. Class size (CLASIZE) was positively related to students' achievement for Korea and Hong Kong, but not for other countries. Teacher's perception of teaching mathematics classes with few or no limitations on instruction due to student factors (PERCPLIMT) was positively related to mathematics achievement in all countries except Japan. In addition, most "teacher's interaction with their colleagues" (INTERACTION) and "involvement in professional development activities" (PROFDEVELOP) variables were unrelated to mathematics achievement across the six nations.

Table 5
The Summery of Parameter Estimates of Model-C across Six Nations or Regions (Student-principal Model)

School-effects Models						
Parameter Estimates	KOR	JPN	TWN	U.S.	SGP	HK
PARENTEDU	NS	(+)	NS	(+)	NS	(-)
ASP	(+)	(+)	(+)	(+)	(+)	NS
VALUE	(+)	(+)	(+)	(-)	(+)	(+)
SLCONF	(+)	(+)	(+)	(+)	(+)	(+)
TMHW	(-)	(-)	(+)	(+)	(+)	NS
TUTORING	(-)	(+)	(-)	(+)	(+)	(+)
AVABLCOMP	(+)	(+)	(+)	(+)	(+)	(+)
NRBOOK	(+)	(+)	(+)	(+)	(+)	NS
LOWSES	(-)	NS	(-)	(-)	NS	NS
HIGHSES	NS	NS	(+)	(+)	NS	NS
GROUPCURRICULUM	NS	NS	NS	NS	.	(-)
GROUPSTUD	NS	NS	NS	NS	NS	NS
SCHCLIMATE	(+)	NS	NS	NS	(+)	NS
GOODSCH	NS	NS	NS	(+)	NS	(+)
SCHSIZE	(+)	NS	NS	NS	(+)	(+)

Statistical Method-2: Variable Ordering

For the purpose of examining school-associated and outside of school variables in a single model, and hence allowing us to order the school and outside of school variables in terms of their relative importance, we conducted multiple regression analyses and used the Relative Pratt Index (Thomas, Hughes, & Zumbo, 1998; Thomas & Zumbo, 1996) to partition the proportion of variance accounted for by the eight outside of school variables and the 31 school-level (teacher and principal) variables.

Table 6

The Summery of Parameter Estimates of Model-C across Six Nations or Regions (Student-teacher Model)

School-effects Models						
Parameter Estimates	KOR	JPN	TWN	U.S.	SGP	HK
PARENTEDU	NS	(+)	NS	(+)	NS	NS
ASP	(+)	(+)	(+)	(+)	NS	NS
VALUE	(+)	(+)	(+)	NS	(+)	(+)
SLCONF	(+)	(+)	(+)	(+)	(+)	(+)
TMHW	NS	(-)	(+)	NS	NS	NS
TUTORING	(-)	(+)	(-)	(+)	(+)	(+)
AVABLCOMP	(+)	(+)	(+)	(+)	(+)	NS
NRBOOK	(+)	(+)	(+)	(+)	NS	(+)
PERCPLIMIT	(+)	NS	(+)	(+)	(+)	(+)
EMHW	NS	NS	NS	(+)	(+)	(+)
CLASIZE	(+)	NS	NS	NS	NS	(+)
MATHTOPICS	NS	NS	NS	(+)	(+)	(+)
TCHTIME	NS	(+)	NS	NS	(-)	NS
INTERACTION (discuss concept)	NS	NS	NS	NS	NS	NS
INTERACTION (prepare instruction material)	NS	NS	NS	NS	NS	NS
INTERACTION (observe others' teaching)	NS	NS	NS	(-)	NS	NS
INTERACTION (observation of teaching by others)	NS	NS	NS	NS	NS	NS
PROFDEVELOP (content)	NS	NS	NS	NS	NS	NS
PROFDEVELOP (pedagogy)	NS	NS	NS	NS	(-)	NS
PROFDEVELOP (curriculum)	NS	NS	NS	NS	(+)	NS
PROFDEVELOP (technology)	NS	NS	(-)	NS	NS	NS
PROFDEVELOP (improve students' problem solving)	NS	NS	NS	NS	NS	NS
PROFDEVELOP (assessment)	NS	NS	NS	NS	NS	NS
CONTENTACT (adding)	(+)	NS	NS	NS	NS	NS
CONTENTACT (fractions)	NS	NS	NS	NS	NS	NS
CONTENTACT (no obvious solution)	NS	NS	NS	NS	NS	NS
CONTENTACT (interpret data in tables, etc.)	NS	NS	NS	NS	(-)	NS
CONTENTACT (write equations and functions to represent relations)	NS	NS	(+)	NS	(+)	NS
CONTENTACT (work in small groups)	NS	NS	NS	NS	NS	NS
CONTENTACT (relate to daily life)	NS	NS	NS	(-)	NS	NS
CONTENTACT (explain their answers)	NS	NS	NS	NS	NS	NS
CONTENTACT (decide own procedures for solving complex problems)	NS	NS	NS	(+)	(+)	NS

The *R*-squared values for each country are reported at the bottom of Table 7. The *R*-squared values ranged from .40 (KOR) to .61 (HK). Given that variables reflecting the students' cognitive abilities were not included in the model (TIMSS did not measure these variables), this range of *R*-squared values were satisfactory for the purpose of this study. The Relative Pratt Indices that partitioned the explained variance into school and outside of school components are presented in Figure 2 and Table 8. The results indicated that outside of school factors explained a large proportion of variance, ranging from 36% to 94% across six countries, but the explained variance by in and out of school factors showed differing patterns across five Asian countries. Figure 2 shows that for KOR, TWN, and JPN, outside of school factors accounted for a substantial proportion of the explained variation in students' achievement, 94% (KOR), 89% (TWN), and 87% (JPN). As for U.S., school-associated factors accounted for slightly more of the explained variation (29%) compared to KOR, TWN and JPN, despite the fact that outside of school factors still accounted for 71% of the explained variance. For SGP and HK, school-associated factors accounted for quite a large proportion of explained variation, 59% (SGP) and 64% (HK). The results echoed those found in HLM Method-1, in which Singapore and Hong Kong exhibited quite different patterns in school and outside of school effects from that of the other three Asian countries. The cross-country pattern of school vs. outside of school factors shown in Figure 2 was consistent with those revealed by the intraclass correlations in Method-1 (Table 3). Figure 2 showed that school-associated variables accounted for a small proportion of the explained variance, .06 (KOR), .13 (JPN), and .11 (TWN). Echoing Figure 2, the intraclass correlations were .10, .15, and .30 for KOR, JPN, and TWN, indicating that school-associated variables accounted for a small proportion of variance in average mathematics scores; however, school-associated variables accounted for a large proportion for US, SGP and HK.

In order to determine which school or outside of school variables are more important variables for explaining students' mathematics achievement, we retained variables that accounted *R*-squared > 0.02 (see our explanation in the *Method* section) and ordered these variables using Relative Pratt Index. Table 8 lists the results of this variable ordering. Overall, self-confidence (SLCONF) was the most important factor related to students' achievement across nations except Singapore where SLCONF was the second most important variable. Students' educational aspirations relative to their parents' education (ASP),

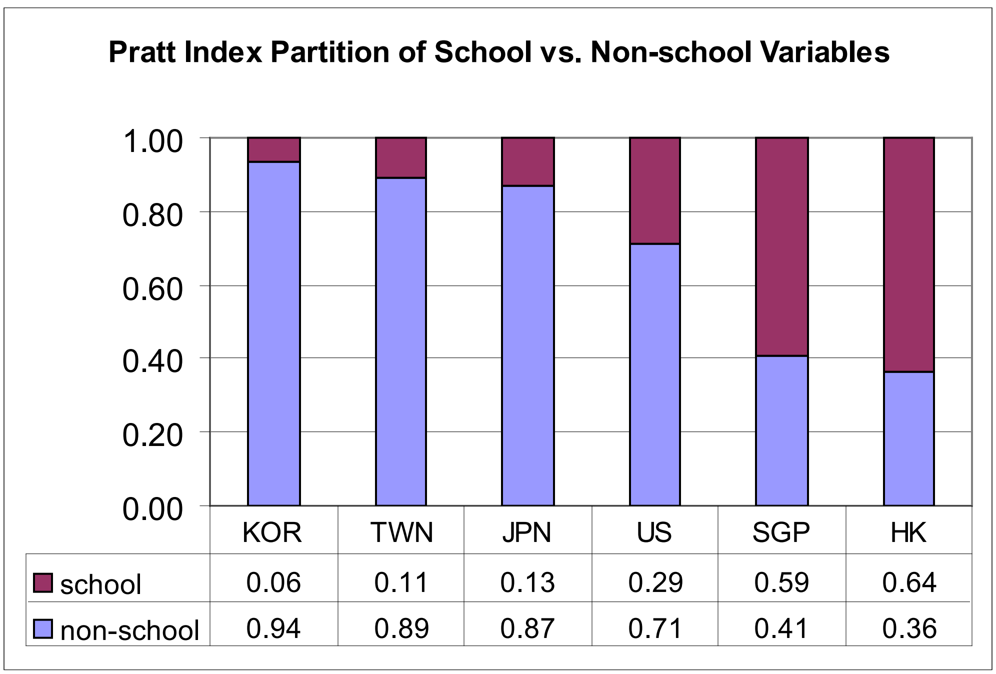
Table 7

R-square Accounted for by School and Outside of school Variables across Six Nations or Regions

	KOR	TWN	JPN	U.S.	SGP	HK
Outside of school	0.44 (94%)	0.47 (89%)	0.35 (87%)	0.37 (71%)	0.23 (41%)	0.22 (36%)
School	0.03 (6%)	0.06 (11%)	0.05 (13%)	0.15 (29%)	0.34 (60%)	0.39 (64%)
Total R-squared	0.47	0.53	0.40	0.52	0.57	0.61

Figure 2

The Pratt-Index Partition of Variances Accounted for by School and Outside of school Variables across Six Nations or Regions



number of books at home (NRBOOK), and the availability of computers at both home and/or school (AVLBLCOMP) were identified as important factors for all nations except Hong Kong, which was consistent with the findings from Method-1. With regard to school-associated factors, teachers' perception of no or few limitations on instruction due to students (PERCPLIMT) and emphasis on homework (EMHM) were also found to be influential variables for U.S., Singapore, and Hong Kong as indicated in Method-1.

Table 8

Importance Ordering of Variables for Six Nations or Regions

KOR			TWN			JPN		
	Pratt	R-sqr		Pratt	R-sqr		Pratt	R-sqr
SLCONF	0.46	0.21	***SLCONF***	0.40	0.21	***SLCONF***	0.40	0.16
NRBOOK	0.19	0.09	***ASP***	0.14	0.07	***ASP***	0.21	0.09
ASP	0.10	0.05	***NRBOOK***	0.13	0.07	***NRBOOK***	0.09	0.04
VALUING	0.07	0.03	LOWSES	0.04	0.02	PARENTEDU	0.06	0.03
SCHSIZE	0.05	0.02	TUTORING	0.04	0.02	***AVLBLCOMP***	0.06	0.02
AVLBLCOMP	0.05	0.02	***AVLBLCOMP***	0.04	0.02	TCHTIME	0.06	0.02
TUTORING	0.04	0.02	CONTENTACT (write equations)	0.03	0.02			
			VALUING	0.03	0.02			
			MCFL	0.03	0.02			
	0.96	0.44		0.88	0.47		0.88	0.36

U.S.			SGP			HK		
	Pratt	R-sqr		Pratt	R-sqr		Pratt	R-sqr
SLCONF	0.24	0.13	MATHTOPICS	0.24	0.13	***SLCONF***	0.18	0.11
NRBOOK	0.13	0.07	***SLCONF***	0.15	0.09	CLASIZE	0.18	0.11
TUTORING	0.11	0.06	SCHCLIMATE	0.10	0.05	GROUPINSTRUT	0.15	0.09
SCHCLIMATE	0.06	0.03	SCHSIZE	0.06	0.04	GOODSCH	0.07	0.04
MATHTOPICS	0.05	0.02	***NRBOOK***	0.06	0.03	***MCFL***	0.05	0.03
CONTENTACT (write equations)	0.05	0.02	***MCFL***	0.05	0.03	***EMH***	0.05	0.03
MCFL	0.05	0.02	***EMH***	0.05	0.03	SCHSIZE	0.04	0.02
ASP	0.04	0.02	CONTENTACT (write equations)	0.04	0.02	INTERACT (observe others' teaching)	0.03	0.02
EMH	0.04	0.02	***ASP***	0.03	0.02	SCHCLIMATE	0.03	0.02
AVLBLCOMP	0.03	0.02	***AVLBLCOMP***	0.03	0.02	PROFDEVELOP (improve students' problem solving)	0.03	0.02
HIGHSES	0.03	0.02	THW	0.03	0.02	CONTENTACT (explain their answers)	0.02	0.02
PARENTEDU	0.03	0.02	CONTENTACT (decide own procedures for solving complex problems)	0.03	0.02			
	0.86	0.45		0.87	0.50		0.83	0.51

Conclusion and Discussion

The purpose of this study is to investigate how outside of school factors, in the presence of school-associated factors, are related to students' mathematics achievement for the U.S. and the five top-performing Asian nations or regions (i.e., Korea, Taiwan, Japan, Singapore, and Hong Kong), and to examine whether the relative role of school-associated and outside of school factors is consistent across the five Asian countries. Hence, this study intends to indirectly test the tacit assumption that higher mathematics performance in these top-performing countries is an outcome of their superior school systems. This tacit assumption may be unfounded because it is unclear how much of the Asian countries' success in mathematics test performance is related to the public school systems and how much to the outside of school factors.

The results obtained from two statistical procedures are quite similar, identifying the similar factors that have effects on students' mathematics achievement. The cluster effect of the data has little influence on the relative Pratt indices for two reasons. First, as a result of a large number of school level variables included in the multiple regression model, the dependence of variance may have well been (inadvertently) accounted for. In addition, the cluster effect has little influence on the elements needed to compute relative Pratt index, which are standardized β weights, R^2, and simple bivariate correlation. In general, our findings suggest that students' mathematics achievement is highly related to outside of school factors such as students' self-confidence in learning mathematics, students' valuing the importance of mathematics, the availability of computers in school and/or home, and extra lesson or tutoring across all six nations or regions. Using the Pratt Index, the percentage of explained variance attributable to outside of school factors ranged from 36% for Hong Kong to 94% for Korea. Having said that, school-associated factors are found to be related to mathematics achievement to a varying degree across the six countries. School-associated factors play little role in students' mathematics achievement for Korea, Taiwan, and Japan. However, for Singapore and Hong Kong, the school-associated factors are substantially related to students' performance and more interestingly, school-associated factors have somewhat more important roles than the outside of school factors. As for the U.S., school-associated factors are related to students' performance; however, the outside of school factors clearly play more salient roles than the school associated factors.

It is worth noting that the belief by some policy makers and educators that the five TIMSS top-performing countries share a homogeneous educational system is an inaccurate stereotype. We have observed similar patterns shared by Korea, Taiwan, and Japan where the school-associated factors play an insignificant role. Similar patterns are found in Singapore and Hong Kong where school-associated factors play a relatively more salient role in mathematics achievement. It should be noted that the relative role of in and out of school factors is not related to the ranking of these Asian nations or regions in TIMSS mathematics tests. For instance, Korea ranks second after Singapore and ahead of Hong Kong, but Korea does not share a similar pattern with Singapore and Hong Kong. Any researchers or educational policy makers who are interested in international education models should note that the role of school-associated factors varies across these top-performing Asian nations while the outside of school factors play a salient role for all of them. Therefore there is no unitary "Asian Model."

In the past two decades, U.S. educators and policy-makers have explored the Japanese educational system and paid great attention to Singaporean education, trying to look for a solution to improve the performance of their students in mathematics. The past and current efforts in the U.S. to incorporate aspects of the Singaporean school system seem to have some empirical support judging by the findings in Tables 5 and 6 that the U. S. achievement attribution pattern is closer to those of Singapore. However, our findings reveal that earlier efforts in adapting the Japanese educational model was less justified because only 13% of explained variation in the Japanese students' performance is related to school-associated factors and only one school associated variable in HLM models is related to students' performance.

The recent attempts in adapting Singapore's educational model may appear to be more promising. This statement does not imply that incorporating Singaporean school model would guarantee an improvement in students' mathematics performance in the U.S. Instead, what we are suggesting is that if any of the attempts to incorporate an Asian education model are to be made by the U.S. policy makers and reform specialists, then a close look into the appropriateness of incorporating a Singaporean or even Hong Kong model would be relatively more promising than other Asian models. It is important to keep in mind, however, that our statistical models were aimed at accounting for variation within the six nations or regions instead of the differences among the six countries or regions. Therefore, one should keep in mind that not all of the schools in, for example, Singapore were superior performing schools – that is, there is within country variation, which we did not investigate in this study. Future research may find it fruitful to contrast high and low performing schools in each of these countries to better understand the educational processes.

It is, of course, very important that one keep in mind that our findings should be interpreted as associations or relationships among variables and not causatively. For example, our HLM analyses show that school size is positively related to Singaporean and Hong Kong students' achievement, and so is class size. An intuitive, but incorrect, conclusion would be that increasing class or school size would increase students' performance. Such a causative statement is not supported by our analyses and data. For example, a simple alternative rival hypothesis to the class or school size conclusion could be that well-performing schools attract more students; hence, as a result, school size and class size get larger. A policy decision based on causal interpretation with correlational data is certainly unjustified.

Finally, we would like to restate that the classification of school-associated (i.e., teacher and principal) and outside of school factors could raise some concern about our interpretations. We frankly acknowledge that it is possible that different classification may lead to different conclusions and interpretation. Our classification was based on the design of TIMSS data collection and also determined by the technical requirement of our data analysis (i.e., HLM). Although HLM is capable of technically dividing variables into school-associate and outside of school variables by the data structure, it could be practically impossible to meaningfully distinguish an outside of school variable from a school-associated variable. For instance, the school socioeconomic status (SES) is the average or sum of individuals' SES, and hence it is unreasonable to think that the school level SES effect is totally distinct from individuals' SES. Another example is the variable that surveyed teachers' perception of no or few limitations on classroom instruction due to student factors (PERCPLIMITATION). Because this variable was collected at the teacher/classroom level, as a result, we could only model it at the second level.

Our central message to the readers is to remind them that a country's educational system is not an isolated component from the society, but is deeply embedded in the culture, family and personal characteristics, as well as the politics and economy of a country. Our empirical findings remind us that mathematics achievement is related to many (if not all) of these variables. Students do not study within a vacuum of a school, rather, are living organisms that interact with other elements of their school and non-school environments. As obvious as this seems, as educational researchers and educational testing specialists we still sometimes carry about our research and educational policy development tacitly assuming otherwise.

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Appendix

Table 1A
Multilevel Estimates for Mode-C (Student-principal Model)

	Parameter	Coefficient					
School-model		**KOR**	**JP**	**TW**	**U.S.**	**SGP**	**HK**
Fix effect							
Intercept	γ_{00}	570.5***	529.5***	602.3***	434.7***	495.6***	442.1***
LOWSES	γ_{01}	-5.3**	***-4.8***	-16.2***	-10***	***-4.8***	***-2.2***
HIGHSES	γ_{02}	2.8***	***1.8***	8.2*	5.5*	***3.8***	***5.5***
GROUPCURRICULUM	γ_{03}	***-2.9***	***-2.3***	***5.9***	***3.2***	-	-31.1**
GROUPSTUD	γ_{04}	***3.8***	***7.2***	***-4.7***	***3.8***	***4.0***	***4.7***
SCHCLIMATE	γ_{05}	6.2*	***9.5***	***4.1***	***8.1***	24.7***	***15.5***
GOODSCH	γ_{06}	***0.9***	***3.7***	***-7.6***	10.48**	***6.0***	22.3*
SCHSIZE	γ_{07}	0.01***	***0.0***	***0.0***	***0.0***	0.03***	0.09**
PARENTEDU	γ_{10}	***0.3***	6.0***	***1.6***	2.3***	***0.8***	-1.6***
ASP	γ_{20}	11.8***	13.5***	17.4***	5.8***	7.0***	***1.5***
VALUE	γ_{30}	9.5***	5.6***	7.0***	-2.52*	7.5***	5.1***
SLCONF	γ_{40}	40.1***	35.1***	43.8***	27.4***	22.2***	25.2***
TMHW	γ_{50}	-3.4*	-10.6***	4.3**	10.3***	13.4***	***0.3***
TUTORING	γ_{60}	-4.0***	3.1**	-5.6***	17.6***	3.1*	7.8***
AVABLCOMP	γ_{70}	12.8***	7.7***	10***	6.1***	10.1***	4.4**
NRBOOK	γ_{80}	12.3***	7.4***	11.2***	8.0***	6.1***	***1.1***
Random effect							
Level-1 variance	σ_{ε}^{2}	3,179***	3,048***	3,657***	2,140***	2,168***	1,366***
Level-2 variance	σ_{u0}^{2}	151***	604***	1,012***	846***	659***	1,792***
Goodness-of-fit	Deviance	49,786	35,196	51,388	54,376	48,371	32,097

Note: *** denotes α significance level at .001, ** at .01, * at .05.
The table only reported the level-2 variance of random effect, as no variable was included into the random coefficient as outcome equations except intercept.

Table 2A

Multilevel Estimates for Mode-C (Student-teacher Model)

	Parameter	Coefficient					
Teacher-model		**KOR**	**JP**	**TW**	**U.S.**	**SGP**	**HK**
Fix effect							
Intercept	γ_{00}	540.8***	485.3***	530.1***	327.5***	267.0***	305.2***
PERCPLIMIT	γ_{01}	7.3***	***6.3***	10.3*	19.8***	26.4***	15.6*
EMHW	γ_{02}	***-0.3***	***4.5***	***4.1***	27.5***	19.1***	15.9*
CLASIZE	γ_{03}	6.6**	***4.5***	***2.6***	***-4.7***	***5.1***	38.3***
MATHTOPICS	γ_{04}	***0.0***	***-0.1***	***0.3***	1.3***	3.4***	1.3**
TCHTIME	γ_{05}	***0.1***	0.3***	***0.1***	***0.0***	-0.3***	***0.0***
INTERACTION 1	γ_{06}	***-1.6***	***0.6***	***-3.5***	***-1.9***	***-3.1***	***-3.2***
INTERACTION 2	γ_{07}	***0.5***	***0.2***	***-1.9***	***3.2***	***-3.7***	***6.0***
INTERACTION 3	γ_{08}	***2.9***	***0.3***	***-5.9***	-17.4***	***-9.9***	***-9.6***
INTERACTION 4	γ_{09}	***1.2***	***-5.0***	***6.5***	***3.9***	***0.7***	***8.1***
PROFDEVELOP 1	γ_{010}	***4.7***	***-6.9***	***6.6***	***11.4***	***1.8***	***-5.3***
PROFDEVELOP 2	γ_{011}	***-0.3***	***7.4***	***-11.1***	***8.3***	-21.2*	***-12.9***
PROFDEVELOP 3	γ_{012}	***3.5***	***-1.8***	***-11.5***	***-12.5***	19.7*	***3.2***
PROFDEVELOP 4	γ_{013}	***-2.3***	***-1.2***	-19.1*	***-5.3***	***9.4***	***-9.8***
PROFDEVELOP 5	γ_{014}	***2.0***	***-1.3***	***0.5***	***3.8***	***11.6***	***6.9***
PROFDEVELOP 6	γ_{015}	***-6.6***	***-0.2***	***8.2***	***-3.5***	***-13.1***	***-6.1***
CONTENTACT 1	γ_{016}	4.2*	***0.0***	***-1.8***	***0.7***	***-2.8***	***-10.9***
CONTENTACT 2	γ_{017}	***-2.8***	***1.5***	***-1.4***	***-1.2***	***6.6***	***9.8***
CONTENTACT 3	γ_{018}	***4.4***	***2.8***	***5.5***	***0.7***	***-2.8***	***-4.3***
CONTENTACT 4	γ_{019}	***-1.8***	***-7.0***	***-14.0***	***-6.2***	-34.9**	***-7.3***
CONTENTACT 5	γ_{020}	***-1.0***	***5.3***	21.6***	***5.2***	19.9***	***11.4***
CONTENTACT 6	γ_{021}	***-2.0***	***-6.2***	***-1.1***	***3.7***	***11.0***	***-4.6***
CONTENTACT 7	γ_{022}	***-2.5***	***1.3***	***-11.5***	-19.7***	***5.2***	***-0.5***
CONTENTACT 8	γ_{023}	***0.6***	***4.1***	***-5.2***	***-5.8***	***-6.8***	***-3.0***
CONTENTACT 9	γ_{024}	***-0.8***	***1.0***	***8.6***	9.0*	10.6*	***-0.1***
PARENTEDU	γ_{10}	***-0.2***	5.2***	***2.0***	1.9**	***-0.7***	***-1.0***
ASP	γ_{20}	13.0***	13.3***	18.0***	2.5***	***-0.8***	***0.8***
VALUE	γ_{30}	11.4***	4.5***	6.1***	***-1.4***	8.2***	5.1***
SLCONF	γ_{40}	38.3***	35.6***	44.1***	22.6***	17.9***	23.4***
TMHW	γ_{50}	***-1.2***	***-11.3***	4.8***	***-1.3***	***0.6***	***0.9***
TUTORING	γ_{60}	-3.5***	3.2**	-5.7***	14.9***	3.5***	8.5***

AVABLCOMP	γ_{70}	12.5***	7.7***	9.3***	3.3***	3.9***	***2.9***
NRBOOK	γ_{80}	12.8***	7.7***	11.5***	6.0***	***0.7***	2.4***
Random effect							
Level-1 variance	σ_{ε}^{2}	3,124	3,038	3,731	1,504	853	1,243
Level-2 variance	σ_{u0}^{2}	226	354	887	1,902	2,839	1,658
Goodness-of-fit	Deviance	30,611	34,435	48,372	45,390	42,971	37,541

Note: *** denotes α significance level at .001, ** at .01, * at .05.
The table only reported the level-2 variance of random effect, as no variable was included into the random coefficient as outcome equations except intercept.