Multilevel Effects of Student and Classroom Factors on Elementary Science Achievement in Five Countries
Sibel Kaya*; Diana C. Rice*  
*Florida State University, USA  
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This study examined the effects of individual student factors and classroom factors on elementary science achievement within and across five countries. The student-level factors included gender, self-confidence in science and home resources. The classroom-level factors included teacher characteristics, instructional variables and classroom composition. Results for the USA and four other countries, Singapore, Japan, Australia and Scotland, were reported. Multilevel effects were examined through Hierarchical Linear Modelling, using the Trends in International Mathematics and Science Study 2003 fourth grade dataset. Overall, the results showed that selected student background characteristics were consistently related to elementary science achievement in countries investigated. At the student level, higher levels of home resources and self-confidence and at the classroom level, higher levels of class mean home resources yielded higher science scores on the TIMSS 2003. In general, teacher and instructional variables were minimally related to science achievement. There was evidence of positive effects of teacher support in the USA and Singapore. The emphasis on science inquiry was positively related to science achievement in Singapore and negatively related in the USA and Australia. Recommendations for practice and policy were discussed.

Keywords: Elementary school; Science education; Quantitative research; Comparative study; Teacher

Introduction

Internationally, the performance of US students in mathematics and science has long been scrutinized. For example, in the Trends in International Mathematics and Science Study (TIMSS) that assesses fourth and eighth grade students on maths and

In recent years, influential policy reports emphasizing the poor performance of US students in science and mathematics compared to other developed countries have highlighted the need for reform in science education in the USA (NAS, 2006; NSB, 2007; US Department of Education, 2000). The NAS (2006) emphasized that improving K-12 science and mathematics education must be a top priority if all students are to receive quality academic preparation at all levels in the fields of science, technology, engineering and mathematics necessary for the USA to be competitive in a global economy.

The interest in raising levels of achievement in maths and science has led to a focus on investigating the factors that shape achievement in these subjects (Lamb & Fullarton, 2002) as well as understanding how these factors operate across countries (Baker, Fabrega, Galindo, & Mishook, 2004). The purpose of this study was to explore the effects of student- and classroom-level factors on students’ science achievement at the elementary level within and across five selected countries: Singapore, Japan, Australia, Scotland and the USA. The TIMSS 2003 data for the five countries were examined using Hierarchical Linear Modelling (HLM) analysis to answer the following research questions:

(1) What student-level factors are significantly related to science achievement at the fourth grade level in Singapore, Japan, the USA, Australia and Scotland?
(2) What classroom-level factors are significantly related to science achievement at the fourth grade level in Singapore, Japan, the USA, Australia and Scotland?
(3) How much of the variance in student achievement is explained by student- and classroom-level factors within and across these five countries?

The TIMSS, sponsored by the International Association for the Evaluation of the Education Achievement on a four-year cycle, has measured mathematics and science achievement of nationally representative samples of students and collected background information from students, their teachers and schools (Martin & Mullis, 2004). This dataset was appropriate for multilevel analysis in which student- and classroom (teacher)-level variables can be included. At the fourth grade, students answered science questions from life, earth and physical knowledge pertaining to factual knowledge, conceptual understanding, and reasoning and analysis. Between one-third and two-fifths of the items were open-ended, the rest of the items were in multiple choice format (Martin & Mullis, 2004).
Forty-eight countries participated in the third TIMSS in 2003 at the eighth grade level and 26 countries participated at the fourth grade level. The database includes data from over 360,000 students, about 25,000 teachers, about 12,000 school principals and research coordinators (Martin & Mullis, 2004). Secondary analyses of the TIMSS 2003 assessment were recommended to help individual countries to better understand their standings in mathematics and science, to identify their strengths and weaknesses and to find ways to improve their educational systems (Martin & Mullis, 2004).

Background

With the 2007–2008 implementation of science testing mandated by the No Child Left Behind Act (2001) have come increasing expectations for improvement in the quality of science instruction (US Department of Education, 2004). However, while considerable research on mathematics and reading achievement has been done (see Darling-Hammond, 2000; Fetler, 1999, 2001; Goldhaber & Brewer, 2000; Hill, Rowan, & Ball, 2005), little research has been published addressing the relations among backgrounds and practices of elementary science teachers and student science outcomes. Considering the poor performance of US students on recent science assessments, the need to explore the effects of teacher characteristics and instructional variables as well as student variables on science achievement seems well justified.

Student-Level Factors and Achievement

The role of gender on students’ science achievement has long been an area of study. In general, boys outperform girls in science (Greenfield, 1996; Jovanovich & King, 1998; Kahle, 2004; Kahle, Parker, Rennie, & Riley, 1993; Morrell & Lederman, 1998). Girls’ lower performance in science has been attributed to various factors such as cultural stereotypes of roles in science (DeBacker & Nelson, 2000; Eisenhart, Finkel, & Marion, 1996), girls’ lack of exposure to science-related activities inside and outside of the classroom (Kahle et al., 1993), decrease in girls’ perceptions of the science ability over time (Jovanovich & King, 1998), gender biases of teachers (Greenfield, 1996) and differences in cognitive abilities (Baron-Cohen, 2003). Gender differences in science at the elementary school level were less common than in the middle school level (Beaton et al., 1996; Greenfield, 1995; Kahle, 2004; Solomon, 1997).

Several studies reported a strong positive relation between students’ science self-efficacy and achievement across grade levels (Britner & Pajares, 2001, 2006; House, 2008; Lau & Roeser, 2002). Bandura (1997) suggested that limited experiences and unfamiliarity with the materials usually determine students’ efficacy judgements. Students who believe that they cannot be successful in science-related activities put minimal effort in completing those tasks, and when they face a challenge, usually give up or experience anxiety (Bandura, 1997). The current study used the science self-confidence index, created by the TIMSS researchers, as an indicator of self-efficacy in learning science (see Table A1 of the Appendix).
Some studies investigating the effects of socioeconomic status (SES) on student achievement showed that parental education, income and occupation were powerful predictors of student achievement (Lytton & Pyryt, 1998; Ma & Klinger, 2004; Manning, 1998; Sammons, West, & Hind, 1997). Others argued that achievement is more closely linked to the measures of the social–psychological environment and intellectual stimulation (Iverson & Walberg, 1982; Stevenson & Stigler, 1992). Educational resources in homes and parental support have been considered to be critical factors for intellectual stimulation (Campbell & Wu, 1994). Studies investigating the relations between home resources and student achievement have found consistent positive relations among these variables (Iverson & Walberg, 1982; Roscigno & Ainsworth-Darnell, 1999; Xin, Xu, & Tatsuoka, 2004).

Classroom-Level Factors and Achievement

The debates over classroom effects on students’ performance started with the Coleman Report (see Coleman et al., 1966). This study attempted to relate family background and school variables to students’ test results and their attitudes by using a large nationally representative sample in the USA. Coleman and colleagues found that student outcomes were unrelated to school characteristics (i.e. the quality of school facilities, programmes and teachers). Instead, academic results were significantly linked to the characteristics of schools’ student bodies. The results raised questions about school policy development and spending. However, according to the critiques there were some flaws in the Coleman Report including improper sampling, multicollinearity among variables and not having longitudinal data (Kahlenberg, 2001; Ladd, 2003). More recently, Lamb and Fullarton (2002) examined the influences of student, classroom and school factors on students’ mathematics achievement in the USA and Australia using the TIMSS dataset. Results showed that most of the between-classroom variation was due to classroom compositional factors in both countries and very little of it was due to differences between teachers.

Studies examining the effects of teacher characteristics on student achievement have reported mixed results. Some indicated that students were more successful in maths and science when their teachers had more years of teaching experience (Fetler, 1999; Greenwald, Hedges, & Laine, 1996), a major degree in the subject taught (Darling-Hammond, 2000; Goldhaber & Brewer, 2000) and post-baccalaureate education (i.e. master’s degree) (Darling-Hammond, 2000). Others reported no relations between student achievement and either teachers’ experience (Ferguson & Ladd, 1996; Goldhaber & Brewer, 2000; Monk, 1994) or teachers’ education (Croninger, Rice, Rathbun, & Nishio, 2007; Goldhaber & Brewer, 2000; Wenglinsky, 2002; Xu & Gullosino, 2006). In general, studies have shown that when their teachers were more supportive and caring, students tended to have higher levels of achievement (Brown, Anfara, & Roney, 2004; Klem & Connell, 2004) and motivation (Klem & Connell, 2004; Marks, 2000).

In terms of instructional factors, the emphasis on science inquiry improved students’ science achievement (House, 2006; Lee, Deaktor, Hart, Cuevas, & Enders,
2006; Paris, Yambor, & Packard, 1998; Stohr-Hunt, 1996). For quality science instruction, providing opportunities for students to conduct inquiry which involves investigating, experimenting, and problem solving was recommended (AAAS, 1993; NRC, 1996). Besides quality, the amount of science instruction has also been emphasized in the National Science Education Standards (NRC, 1996) and in various school learning models (Biggs & Moore, 1993; Bloom, 1976; Carroll, 1963; Walberg, 1986). The amount of time spent on subject content, in general, has been shown to positively affect student achievement (Bodovsky & Farkas, 2007; Coates, 2003). However, the results were inconclusive for studies investigating the relation between the amount of science instruction and science achievement (Baker et al., 2004; Coates, 2003). Finally, while positive effects of smaller class size on student achievement have been documented (Finn & Achilles, 1999; Mitchell & Mitchell, 1999; Smith, Molnar, & Zahorik, 2003), internationally, research has suggested little evidence of the effect of class size on student achievement (Pong & Pallas, 2001; Woessman & West, 2002).

**Conceptual Model**

A variety of school learning models have been developed to organize the student-, classroom-, and school-based variables related to student learning. While no single model can completely explain “how learning occurs”, it is apparent that learner characteristics and classroom variables are crucial components of the teaching/learning process. Models have suggested that student achievement is directly affected by learner characteristics including gender (Biggs & Moore, 1993), SES (Biggs & Moore, 1993; Walberg, 1986) and students’ affective characteristics, such as academic self-beliefs (Biggs & Moore, 1993; Bloom, 1976; Carroll, 1963). Other factors identified as having direct impact on learning outcomes include teacher characteristics such as experience and knowledge (Biggs & Moore, 1993; Carroll, 1963) and classroom variables including quality (Biggs & Moore, 1993; Bloom, 1976; Carroll, 1963; Walberg, 1986) and quantity of instruction (Carroll, 1963; Walberg, 1986) and class size (Biggs & Moore, 1993).

To understand better how student and classroom factors relate to science achievement the following conceptual model was developed based on the previous school learning models (see Figure 1). In this model, there were two clusters of factors: student and classroom variables.

For student-level factors, gender, home resources and science self-confidence were drawn from the TIMSS 2003 student questionnaire. Home resources was derived for the current study based on students’ responses to survey questions about having a computer, a study desk and about the number of books in their homes.

For classroom-level factors, teacher characteristics, instructional variables and classroom composition were included. Three teacher characteristics related to their educational and professional attainment were drawn from the TIMSS 2003 teacher questionnaire: years of teaching experience, highest level of education and major area of study. A fourth teacher variable, teacher support, was defined for this
study based on students’ responses to the statements about teacher care and expectation.

Three instructional variables were included in the analyses: amount of weekly science instruction, class size and science inquiry. Both the amount of weekly science instruction and class size were taken from the TIMSS 2003 teacher questionnaire. For the study, five student questionnaire items identified by TIMSS as inquiry items were used to derive the science inquiry variable. These items were related to planning, observing and conducting experiments, explaining science concepts and working in groups (see Table A1). The description of the development of this variable is presented in the “Methods” section.

Classroom composition was defined by two variables: class mean of home resources and class mean of science self-confidence. As indicated in Figure 1, it was hypothesized that both student- and classroom-level factors directly affected students’ science outcomes. It was further hypothesized that student-level factors might have been mediated by classroom-level factors.

**Methods**

**Sample**

Fourth grade students and their teachers in five countries participating in the TIMSS 2003 assessment, including the USA, were the sample of this study. Sample sizes for the countries along with the descriptives are presented in Table A2 of the Appendix. Singapore was selected because it was the top scoring country. Japan was selected because of its high TIMSS scores and because it is a country that has often
been compared with the USA. Australia and Scotland are English-speaking countries that both scored lower than the USA. Furthermore, both Australia and Scotland have decentralized education systems as does the USA (Bray, 2007; The Scottish Government, 2008). Although the degree varies across countries, in general, *decentralization of education* means shifting the governance of education from a central level to lower levels of administration, such as provincial, district and community levels (UNESCO, 2006). In decentralized systems such as Scotland, schools are not mandated to use a proscribed national curriculum (The Scottish Government, 2008).

**Variables**

Science achievement score (five plausible values) at fourth grade level on the TIMSS 2003 test was the dependent variable in the study. The TIMSS 2003 data provided information about students and their home characteristics, teachers and classroom instruction for each country. Guided by previously developed models of school learning (Biggs & Moore, 1993; Bloom, 1976; Carroll, 1963; Walberg, 1986) and the science education literature, this study examined three independent variables at the student level and nine variables at the classroom level that pertained to children’s learning. The student variables, gender (GENDER), home resources (HOMERES) and science self-confidence (SELFCON), were drawn from the TIMSS 2003 student questionnaire. Home resources variable was an index based on students’ responses to questions about educational resources (number of books at home, having a computer and study desk) at home. *High level* indicated that students have a computer, study desk and more than 100 books in home. *Low level* indicated having neither a computer nor a study desk and having less than 25 books in home. Science self-confidence index was created by the TIMSS 2003. Accordingly, students in the study had *low*, *medium* and *high* levels of self-confidence in science (see Table A1).

Four of the classroom-level variables were teacher-related. Three teacher variables that pertained to educational and professional attainment characteristics were drawn from the TIMSS 2003 teacher questionnaire. These were years of teaching experience (TEXP), the highest level of formal education (TEDUC) and having a science or mathematics major (TMAJOR). A fourth teacher-related variable, the teacher support (TSUPPORT), was created based on students’ responses to two statements about teacher care and expectation (see Table A1). Raw scores were added to create this variable.

The three instructional variables were science inquiry (SCINQ), the minutes of weekly science instruction (SCIMIN) and class size (CLASSIZE). The TIMSS 2003 study identified five instructional variables as science inquiry variables. Students’ reports of the frequency of five types of science activities were added to create SCINQ. Although teachers might report that they make efforts to meet students’ instructional needs, students’ perceptions and interpretations of these efforts are important (Daniels & Perry, 2003). Therefore, this study utilized student...
reports on science inquiry items. To assure the construct validity, factor analysis was conducted on these five variables for each country. The analysis with maximum likelihood extraction revealed only one factor solution in each country. Thus, using science inquiry as a single construct for those five variables was appropriate. SCIMIN, which was a continuous variable, was teacher’s response to how many minutes are spent in science instruction weekly. CLASSIZE was a categorical variable, based on teacher’s response to how many students are in class for science instruction. Finally, two classroom composition variables, class mean of home resources (M_HOMERES) and science self-confidence (M_SELFCON), were used at the classroom level. More detailed description of the variables and descriptive statistics can be found in the Appendix.

Using the same teacher background variables for all the countries might have been questioned since each country has different requirements for teachers. Comparative studies have found cultural differences in teachers’ roles and identities across countries (Anderson-Levitt, 2001; LeTendre, 1999). However, a recent report by Wang, Coleman, Coley, and Phelps (2003) indicated that the requirements for teachers and the structure of teacher education programmes have become similar across eight countries: Australia, England, Hong Kong, Japan, Korea, the Netherlands, Singapore and the USA. Therefore, a cross-national comparison using the same teacher characteristics seemed reasonable.

Data Analysis

Education studies commonly have nested data structures, which was the case in the TIMSS 2003 assessment. Many previous non-experimental studies on classroom effects treated classroom and teacher variables as individual student characteristics (Pong & Pallas, 2001). Using a standard multiple linear regression analysis at the student level to examine sources of influence related to student performance is problematic because there are multilevel influences (i.e. student-level and classroom-level) that need to be analysed using multilevel models (Raudenbush & Bryk, 2002).

Two-level HLM analyses were conducted in this study, where students were the Level 1 and classrooms were the Level 2 units. The analysis followed the three-stage approach of multilevel modelling. In the first stage, the analysis produced the unconditional model with no independent variables at the student and the classroom levels. This model provided a measure of the variances within and between classrooms for science achievement. At the second stage (random coefficients model), student-level variables were added to the unconditional model to determine whether their relationships with achievement varied significantly across classrooms. At the last stage (conditional model), classroom-level variables (teacher and instructional variables) were added to the model (Raudenbush & Bryk, 2002).

A multiple imputation HLM procedure was used in which results from the analyses with five plausible values were combined to estimate parameters of correlates of science achievement (Raudenbush & Bryk, 2002). Data were analysed by using the
HLM software version 6.07 and SPSS 15. The HLM analyses were carried out first for each country and then with the data from all five countries combined. Missing data were handled by list-wise deletion and mean imputation. The equations derived from the conditional model for Level 1 and Level 2 are presented in Table 1.

The proportion of variance explained by the final model was computed by subtracting the total variance in the final model (conditional) from the total variance in the unconditional model and dividing by the total variance in the unconditional model.

\[
\text{Reduction} = \frac{\tau_{00}(\text{Unconditional}) - \tau_{00}(\text{Conditional})}{\tau_{00}(\text{Unconditional})}
\]

Finally, data from all five countries were analysed in a similar fashion, by using two-level HLM to make cross-country comparisons. The same three variables were used at the student level (GENDER, SELFCON and HOMERES). Country-specific variables were created and the variables were centred around the grand mean. Based on the results of within-country analyses, at the classroom level, the effects of teacher support (TSUPPORT), science inquiry (SINQ), class mean of science self-confidence (M_SELFCON) and home resources (M_HOMERES) were compared in five countries (see Table 1 for Level 1 and Level 2 equations).

Limitations

The sampling procedures utilized in data collection for the TIMSS 2003 and the results of this study revealed important associations between student- and classroom-level factors and science achievement. However, there were some limitations that should be kept in mind when interpreting the results. First, some of the data used in this study were obtained by questionnaires from students and teachers who participated in the TIMSS 2003. Thus, the study is exploratory in nature and could not provide direct evidence of causal effects. The variables, especially the ones related to science instructional practices, might be considered crude and may not reflect the real classroom applications.

Second, the TIMSS does not provide a value-added model in which students’ previous performance is taken into account. Therefore, students’ prior academic level could not be used in the HLM analyses. In value-added models, improvement in performance can be more easily related to classroom and school inputs (Hanushek, 1997). On the contrary, in studies that do not use previous achievement, student performance correlates with other variables (Hanushek, 1997; Raudenbush & Bryk, 2002; Xin et al., 2004). If successful students, for example, were assigned to teachers with higher qualifications, one would expect an upward bias for teacher effect (Xin et al., 2004).

Third, the TIMSS 2003 fourth grade data did not provide adequate information about family background, especially SES and parents’ education. Research indicates that family background variables explain a substantial amount of variance in student
### Table 1. Level 1 and Level 2 equations for conditional models

<table>
<thead>
<tr>
<th>Individual country analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1</strong></td>
</tr>
<tr>
<td>SCIENCE PV's  ( s_{ij} ) =  ( \beta_0j + \beta_1j(GENDER) + \beta_2j(SELFCON) + \beta_3j(HOMERES) + r_{\bar{y}} )</td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
</tr>
<tr>
<td>( \beta_{0j} = \gamma_{00} + \gamma_{01}(TEXP)<em>j + \gamma</em>{02}(TEDUC)<em>j + \gamma</em>{03}(TMAJOR)<em>j + \gamma</em>{04}(TSUPPORT)<em>j + \gamma</em>{05}(SCINQ)<em>j + \gamma</em>{06}(SCIMIN)<em>j + \gamma</em>{07}(CLASSIZE)<em>j + \gamma</em>{08}(M_SELFCON)<em>j + \gamma</em>{09}(M_HOMERES)<em>j + u</em>{0j} )</td>
</tr>
</tbody>
</table>

\( \gamma_{10} = \) the effect of GENDER on science achievement in classroom \( j \)
\( \gamma_{20} = \) the effect of SELFCON on science achievement in classroom \( j \)
\( \gamma_{30} = \) the effect of HOMERES on science achievement in classroom \( j \)
\( r_{\bar{y}} = \) the error variance at the student-level

\( \gamma_{00} = \) the intercept or the grand mean of the science scores for all classrooms
\( \gamma_{01} = \) the effect of TEXP on class mean achievement
\( \gamma_{02} = \) the effect of TEDUC on class mean achievement
\( \gamma_{03} = \) the effect of TMAJOR on class mean achievement
\( \gamma_{04} = \) the effect of TSUPPORT on class mean achievement
\( \gamma_{05} = \) the effect of SCINQ on class mean achievement
\( \gamma_{06} = \) the effect of SCIMIN on class mean achievement
\( \gamma_{07} = \) the effect of CLASSIZE on class mean achievement
\( \gamma_{08} = \) the effect of M_SELFCON on class mean achievement
\( \gamma_{09} = \) the effect of M_HOMERES on class mean achievement

\( u_{0j} = \) the error variance at the classroom-level
Table 1. (Continued)

<table>
<thead>
<tr>
<th>Cross-Country analyses</th>
</tr>
</thead>
</table>

**Student-level effects**

Level 1

\[
\text{SCIENCE PV's}_j = \hat{a}_{1j}(\text{SING}) + \hat{a}_{2j}(\text{JAPAN}) + \hat{a}_{3j}(\text{USA}) + \hat{a}_{4j}(\text{AUST}) + \hat{a}_{5j}(\text{SCOT}) + \hat{a}_{6j}(\text{SING_GENDER}_i) + \hat{a}_{7j}(\text{JAPAN_GENDER}_i) + \hat{a}_{8j}(\text{USA_GENDER}_i) + \hat{a}_{9j}(\text{AUST_GENDER}_i) + \hat{a}_{10j}(\text{SCOT_GENDER}_i) + \ldots + r_{ij}
\]

Level 2

\[
\begin{align*}
\beta_{1j} &= \gamma_{10} + u_{1j} \\
\beta_{2j} &= \gamma_{20} + u_{2j} \\
\beta_{3j} &= \gamma_{30} + u_{3j} \\
\beta_{4j} &= \gamma_{40} + u_{4j} \\
\beta_{5j} &= \gamma_{50} + u_{5j} \\
\beta_{6j} &= \gamma_{60} \\
\beta_{7j} &= \gamma_{70} \\
\beta_{8j} &= \gamma_{80} \\
\beta_{9j} &= \gamma_{90} \\
\beta_{10j} &= \gamma_{100}
\end{align*}
\]

**Classroom-level effects**

Level 1

\[
\text{SCIENCE PV's}_j = \beta_{0j} + \beta_{1j}(\text{GENDER}_i) + \beta_{2j}(\text{SELFCON}_i) + \beta_{3j}(\text{HOMERES}_i) + r_{ij}
\]

Level 2

\[
\begin{align*}
\beta_{0j} &= \gamma_{01}(\text{SING})_j + \gamma_{03}(\text{JAPAN})_j + \gamma_{04}(\text{USA})_j + \gamma_{05}(\text{AUST})_j + \gamma_{06}(\text{SCOT})_j + \gamma_{07}(\text{SING_TSUPPORT})_j + \gamma_{08}(\text{JAPAN_TSUPPORT})_j + \gamma_{09}(\text{USA_TSUPPORT})_j + \gamma_{09}(\text{AUST_TSUPPORT})_j + \gamma_{010}(\text{SCOT_TSUPPORT})_j + \ldots + u_{0j}
\end{align*}
\]
achievement (Goldhaber, 1999; Lamb & Fullarton, 2002; Ma & Klinger, 2004). Therefore, this study was limited in explaining the variance in science achievement at the student level.

Results

Within-Country Analyses

Variation in science achievement: within vs. between classrooms. According to the unconditional HLM results, within-class variance in Japan, the USA, Australia and Scotland was larger than between-class variance (see Figure 2). Especially in Japan, most of the variance was within classrooms (96%), among the students in the same classroom, taught by the same teacher. Only in Singapore, was within-class variance (47%) smaller than between-class variance (53%).

The effects of student-level variables. To answer the first and second research questions, a conditional model with all the student- and classroom-level variables was run with HLM. The first research question examined the effects of the selected student-level factors on science scores at the fourth grade in five countries. The results showed that there were no significant differences between the science scores of boys and girls in Japan, the USA and Australia. Differences were significant...
(p < 0.05) in Singapore and Scotland. On average, girls scored approximately 7 points lower than boys in Singapore and 12 points lower in Scotland, controlling for the science self-confidence and home resources (see Table 2).

Science self-confidence (SELFCON) and home resources (HOMERES) positively affected the TIMSS 2003 fourth grade science scores (see Table 2). The effects were significant at the p < 0.001 level in all five countries. On average, the increases in the science scores associated with one point increase in science self-confidence were 17 points in Singapore, 20 points in Japan, 22 points in the USA, 25 points in Australia and 16 points in Scotland, controlling for gender and home resources. The increases in the science scores associated with one point increase in home resources were 17, 23, 19, 23 and 16 points, respectively, controlling for gender and science self-confidence.

**The effects of classroom-level variables.** The second research question examined the effects of the selected classroom-level factors on fourth grade science scores in the five countries. In general, there were no significant relations between the teacher’s education and major and the TIMSS 2003 science scores (see Table 2). There was a positive relation between teacher’s experience and students’ science scores only in Japan (p < 0.05). Students achieved 0.40 points higher with each year’s increase in their teacher’s experience controlling for other variables. Teacher support was significantly related to science scores in Singapore and the USA (p < 0.001). Students who perceived their teachers as more supportive tended to achieve higher scores on the science test compared to their counterparts in other classrooms. In Singapore students scored 15 points (46.47×0.32) and in the USA, 11 points (35.50×0.31) higher with one standard deviation increase in the perception of teacher support, when all the other variables were held constant (see Table 2).

The effects of science inquiry (SCINQ) on TIMSS fourth grade science scores were inconsistent (see Table 2). In Singapore, there was a seven-point (4.50×1.58) increase in class mean achievement with one standard deviation increase in the emphasis on science inquiry (p < 0.05), when other variables were held constant. In contrast, for US fourth graders, there was a seven-point (−3.74×1.95) decrease in class mean achievement with every unit increase in the emphasis on science inquiry (p < 0.05). In Australia, Japan and Scotland, there was no relation between science inquiry and science scores. Minutes of weekly science instruction (SCIMIN) and class size (CLASSIZE) did not have significant effects on science scores in any of the five countries examined (see Table 2).

The effect of class mean self-confidence at the classroom level was significant only in the USA (p < 0.05) and Scotland (p < 0.01). On average, students achieved nine points (38.73×0.23) higher in the USA and eight points (38.80×0.21) higher in Scotland on the science test with one standard deviation increase in the class mean self-confidence, controlling for other variables (see Table 2). The effect of class mean home resources (M_HOMERES) was not significant in Japan but positive and significant in the other four countries at p < 0.001 level. In Singapore, classrooms
Table 2. The effects of student- and classroom-level variables on science achievement within countries

<table>
<thead>
<tr>
<th>Type of effect</th>
<th>Singapore</th>
<th>Japan</th>
<th>USA</th>
<th>Australia</th>
<th>Scotland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>SE</td>
<td>Coefficient</td>
<td>SE</td>
<td>Coefficient</td>
</tr>
<tr>
<td><strong>Fixed effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>564.63***</td>
<td>3.96</td>
<td>543.09***</td>
<td>2.14</td>
<td>533.49***</td>
</tr>
<tr>
<td><strong>Student-level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender slope</td>
<td>-6.97**</td>
<td>2.30</td>
<td>-0.84</td>
<td>2.42</td>
<td>-2.43</td>
</tr>
<tr>
<td>Self-confidence slope</td>
<td>16.47***</td>
<td>1.36</td>
<td>20.30***</td>
<td>1.86</td>
<td>21.57***</td>
</tr>
<tr>
<td>Home resources slope</td>
<td>17.12***</td>
<td>2.35</td>
<td>22.69***</td>
<td>3.37</td>
<td>18.50***</td>
</tr>
<tr>
<td><strong>Classroom-level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher’s experience</td>
<td>0.31</td>
<td>0.26</td>
<td>0.40*</td>
<td>0.20</td>
<td>0.28</td>
</tr>
<tr>
<td>Teacher’s education*</td>
<td>-1.78</td>
<td>5.54</td>
<td>3.03</td>
<td>4.27</td>
<td>1.55</td>
</tr>
<tr>
<td>Teacher support</td>
<td>46.47***</td>
<td>11.65</td>
<td>6.51</td>
<td>4.28</td>
<td>35.50***</td>
</tr>
<tr>
<td>Science inquiry</td>
<td>4.50**</td>
<td>1.82</td>
<td>1.18</td>
<td>1.49</td>
<td>-3.74**</td>
</tr>
<tr>
<td>Minutes of science instruction</td>
<td>0.56</td>
<td>0.31</td>
<td>0.06</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>Class size</td>
<td>18.84</td>
<td>9.76</td>
<td>-2.78</td>
<td>1.84</td>
<td>-3.18</td>
</tr>
<tr>
<td>Class mean self-confidence</td>
<td>15.66</td>
<td>16.02</td>
<td>11.45</td>
<td>10.37</td>
<td>38.73*</td>
</tr>
<tr>
<td>Class mean home resources</td>
<td>289.24***</td>
<td>21.74</td>
<td>37.39*</td>
<td>17.30</td>
<td>122.85***</td>
</tr>
<tr>
<td><strong>Random effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance component SD</td>
<td>1135.61</td>
<td>33.87</td>
<td>132.65</td>
<td>11.52</td>
<td>729.26</td>
</tr>
<tr>
<td>Variance component SD</td>
<td>3322.99</td>
<td>57.64</td>
<td>4771.91</td>
<td>69.08</td>
<td>4044.72</td>
</tr>
<tr>
<td>Level 1 variance explained (%)</td>
<td>6.97</td>
<td>5.67</td>
<td>5.91</td>
<td>4.29</td>
<td>4.29</td>
</tr>
<tr>
<td>Level 2 variance explained (%)</td>
<td>71.71</td>
<td>30.35</td>
<td>62.56</td>
<td>42.53</td>
<td>57.19</td>
</tr>
</tbody>
</table>

*Teacher’s Education for Singapore was not included in the final HLM model because there was only one teacher with a master’s or doctoral degree.

*p < 0.05 level, **p < 0.01, ***p < 0.001.

Note: SE = standard error; SD = standard deviation.
with one standard deviation increase in class mean home resources achieved, on average, 46 points (289.24×0.16) higher, controlling for other variables. The increase was 23 points (122.85×0.19) in the USA, 26 points (112.03×0.23) in Australia and 18 points (96.50×0.19) in Scotland.

*Explained variances in science achievement.* The third research question examined the variances in students’ science achievement explained by the selected student- and classroom-level factors in the five countries. Introducing the selected student-level variables into the model reduced approximately 7% of error variance at Level 1 in the USA. In other words, in the USA, about 7% of the student-level variance was explained by science self-confidence and home resources, both of which had significant effects on science achievement. The remaining 93%, however, was accounted for by other variables not included in the model. It should be noted that 69% of the variance in science scores was within classrooms in the USA. In other words, student-level variables explained only about 5% (7×69%) of the total variance.

By introducing the selected classroom-level variables into the model, about 63% of the variance was explained at the classroom level in the USA (see Table 2). The remaining 37% was accounted for by variables not included in the model. It should be noted that 31% of the variance in science scores was between classrooms in the USA. Therefore, the classroom variables in the study explained a total of 19% (63×31%) of the total variance in the TIMSS 2003 fourth grade science scores in the USA. Explained variances at Level 1 and Level 2 for the four other countries are presented in Table 2.

*Cross-Country Analyses*

Combined data from all five countries were analysed in a similar fashion, by using two-level HLM to make cross-country comparisons. The same three variables were used at the student level (gender, self-confidence and home resources). At the classroom level, the variables with some significant effects, namely teacher support, science inquiry, class mean of science self-confidence and home resources, were compared. At the student and the classroom levels, country-specific, dummy coded variables were created. Data from the five countries included 24,233 students at Level 1 and 913 teachers at Level 2. Table 3 shows the cross-country effects of student-level variables. The results of the combined analyses were slightly different from the within-country analyses.

In terms of gender, girls scored significantly ($p < 0.01$) lower than boys on the TIMSS 2003 science test in Scotland and the USA compared to other countries. In Singapore, Japan and Australia, the differences between boys’ and girls’ scores were negligible. Similar to the within-country analyses, at the student level, the effects of science self-confidence and home resources were positive and significant in all five countries ($p < 0.001$) (see Table 3). The three variables explained about 5% of the variance in the TIMSS 2003 fourth grade science scores in the five countries at the student level.
Table 3. The effects of student- and classroom-level variables on science achievement across countries

<table>
<thead>
<tr>
<th>Type of effect</th>
<th>Singapore</th>
<th>Japan</th>
<th>USA</th>
<th>Australia</th>
<th>Scotland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient SE</td>
<td>Coefficient SE</td>
<td>Coefficient SE</td>
<td>Coefficient SE</td>
<td>Coefficient SE</td>
</tr>
<tr>
<td>Intercept</td>
<td>572.78*** 5.34</td>
<td>547.68*** 5.34</td>
<td>535.18*** 5.34</td>
<td>515.35*** 5.34</td>
<td>512.70*** 5.34</td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender slope</td>
<td>0.30 3.63</td>
<td>−0.85 2.38</td>
<td>−4.86** 1.82</td>
<td>−1.17 3.69</td>
<td>−13.67** 4.20</td>
</tr>
<tr>
<td>Self-confidence slope</td>
<td>17.08*** 2.03</td>
<td>19.85*** 1.83</td>
<td>26.44*** 1.84</td>
<td>24.50*** 2.99</td>
<td>17.03*** 2.61</td>
</tr>
<tr>
<td>Home resources slope</td>
<td>50.91*** 4.21</td>
<td>24.13*** 3.45</td>
<td>39.48*** 2.52</td>
<td>26.29*** 3.17</td>
<td>28.48*** 4.44</td>
</tr>
<tr>
<td>Classroom-level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher support</td>
<td>53.02*** 13.19</td>
<td>5.31 6.66</td>
<td>36.07*** 6.77</td>
<td>13.57 8.71</td>
<td>−10.59 10.07</td>
</tr>
<tr>
<td>Science inquiry</td>
<td>4.71* 2.25</td>
<td>0.75 1.93</td>
<td>−3.69* 1.29</td>
<td>−2.73* 1.17</td>
<td>−1.24 1.40</td>
</tr>
<tr>
<td>Class mean self-confidence</td>
<td>−1.12 18.48</td>
<td>−18.73 11.56</td>
<td>19.83 15.82</td>
<td>27.38* 12.85</td>
<td>20.28 13.09</td>
</tr>
<tr>
<td>Class mean home resources</td>
<td>287.97*** 22.29</td>
<td>17.00 20.72</td>
<td>109.62*** 16.24</td>
<td>71.26*** 14.50</td>
<td>79.73*** 18.04</td>
</tr>
<tr>
<td>Random effects</td>
<td>Variance component</td>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between class, ( \mu_0 )</td>
<td>749.77 27.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within class, ( r )</td>
<td>5546.57 74.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1 variance explained (%)</td>
<td>5.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2 variance explained (%)</td>
<td>60.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total variance explained (%)</td>
<td>21.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\*p < 0.05 level, \*\*p < 0.01, \*\*\*p < 0.001.

Note: SE = standard error; SD = standard deviation.
Consistent with the within-country results, teacher support was positively related to students’ science scores in Singapore and the USA in comparison to other countries \((p < 0.05)\) at the classroom level. Science inquiry was found to be negatively related to science scores in Australia and the USA and positively related in Singapore.

The cross-country analysis revealed that the effect of class mean science self-confidence on the science scores was significant only in Australia. Class mean of home resources was positively related to student scores \((p < 0.001)\) in every country except Japan. The four variables, teacher support, science inquiry, class mean home resources and class mean self-confidence, explained approximately 60\% of the variance in fourth grade science scores in the five countries at the classroom level. The student- and classroom-level variables explained approximately 22\% of the total variance in science achievement in the five countries (see Table 3).

**Discussion**

Study results showed that a large portion of the variance in science achievement at the student level remained unexplained for the countries investigated. On the other hand, explained variance between classrooms relative to student level was larger. It is evident that the selected student-level factors, gender, science self-confidence and home resources measured by the TIMSS 2003 questionnaire were not adequate in explaining the individual differences in science achievement. It should be kept in mind that most of the variation in achievement was among students within classrooms (i.e. 96\% in Japan), which means that characteristics among individual students within a classroom were more diverse than the characteristics across classrooms. There are obviously other factors affecting science achievement at the individual level that were not included in this study. For example, research findings suggest that parents’ education level (Lamb & Fullarton, 2002; Xin et al., 2004) and parental involvement in education (Aun, Riley II, Atputhasamy, & Subramaniam, 2006; Bray, 1999; Khong & Ng, 2005; Russell, 1997) have positive influences on student outcomes.

The findings indicated some distinctive characteristics of countries. For example, in Japan the between-class variance was only 4\%, indicating very little difference from one classroom to another, perhaps reflecting its uniform schooling system. Singapore, on the other hand, had the largest between-class variance (53\%) among the five countries, most of which was explained by class mean home resources, possibly a result of stratification of the schooling system in that country.

It was stated that homogeneity across classrooms and schools is common in centralized education systems (Husen & Postlethwaite, 1994) which was the case in Japan. In their analysis of the TIMSS Case Study Project, LeTendre and colleagues (2003) found remarkable differences between Japan and the USA in terms of curricular differentiation and ability grouping. In Japan, there was little or no such differentiation and no ability grouping until high school. In the USA, curricular and
organizational differentiation across classrooms and schools was widespread, beginning in early grades and persisting through high school (LeTendre, Hofer, & Shimizu, 2003).

Despite its centralized education system, Singapore was quite different from Japan with large variation among classrooms. A possible explanation for this heterogeneity across classrooms could be due to Singapore’s highly competitive schooling system (Bracey, 1998; Tan, 1998) and merit-based distribution of scholarships (Mukhopadhaya, 2002). Tan indicated that there is a growing stratification of schools with admissions based on student ability. Students from wealthier families are usually overrepresented in well-established, prestigious schools (Tan, 1998). There is room for future investigation of factors that are associated with Singapore’s superior performance in science.

In terms of explaining the achievement gap among countries, other factors need to be examined. One factor possibly contributing to the superiority of Asian students in science which has not been included in this study could be the parental involvement. Researchers argue that a crucial factor in students’ success in Singapore and Japan, along with other Asian countries, is parental interest and investments in education (Aun et al., 2006; Bray, 1999; Russell, 1997). Parents have high expectations for their children’s education due to the increasingly competitive academic environment (Khong & Ng, 2005) and they invest heavily in private tutoring (Bray, 1999; Bray & Kwok, 2003). For example, Russell (1997) reported that in East Asian countries, nearly 70% of all students had received tutoring by the time they had completed middle school. However, in the USA only 25% of students attend private tutoring outside of school (OECD, 2000). The addition of questions regarding private tutoring on future TIMSS surveys might allow researchers to explore the impact of this variable across countries.

Differences in science curricula across countries might also explain international differences in science achievement (Schmidt & McKnight, 1998). The US science curriculum is considered to be less advanced and of lower depth compared to the top scoring Asian countries (Murdock, 2008; Schmidt, McKnight, & Raizen, 1997). While the curriculum covers more topics, no foundation in physical sciences is provided in the first eight years of US science schooling (Lee, 1999). The use of large databases such as TIMSS to explore relations between curriculum and achievement differences among countries warrants consideration.

Implications

The results of this study suggested that availability of educational resources at home strongly predicted students’ science achievement both at the student and the classroom levels. While there are limits to the impact that educators can have on students’ home environments, improving school and classroom environments could help in promoting science achievement. It is evident that what children bring to classrooms plays an important role in their learning; therefore, developing a knowledge base for teachers regarding the influences of classroom and school composition has been highlighted.
Honig, Kahne, and McLaughlin (2001) proposed that teachers can help target instructional needs, such as coaching and mentoring by becoming more familiar with students’ families and neighbourhoods.

At the classroom and the school levels, policy efforts could focus on the distribution of educational resources and funding. In Japan, for example, the government allocates more resources for schools serving low-SES communities to compensate for poor family background (Goesling, 2005). Unfortunately, in the USA, schools serving students from low-SES families suffer the most from unequal distribution of educational funds (Condron & Roscigno, 2003; Darling-Hammond & Sykes, 2003; Goesling, 2005; Greenwald et al., 1996; Lee & Luykx, 2005). Darling-Hammond and Sykes have observed that inequalities associated with family circumstances are multiplied by inequalities at school and continue throughout students’ educations.

Students’ self-confidence was found to positively predict science scores. To improve students’ self-confidence in science it is recommended that teachers scaffold science activities by accommodating students’ needs and abilities, and by providing them with stimulating tasks and materials (Britner & Pajares, 2006). Through successful modelling, teachers can help students build efficacy beliefs. Science teachers can have students in mixed-ability groups so that more capable students can provide models for lower ability students in science skills (Britner & Pajares, 2006). Efforts may include actively engaging students in science awareness week or month, science fairs and science camps. Moreover, scientists from various demographic groups may be invited to classrooms to interact with students and to share their work and the experiences that led them to careers in science.

While gender was less of a factor in fourth grade science achievement, the evidence of a subsequent widening gender gap by later grades (see Beaton et al., 1996; Greenfield, 1995; Kahle, 2004; Martin et al., 2004; Solomon, 1997) warrants earlier attention. Being aware of the emerging gender differences in science could be critical in terms of providing academic and motivational assistance. Schools and teachers can help break the stereotypes associated with gender by promoting science particularly among girls (Dimitrov, 1999), providing opportunities for all students to perform science (Jovanovic & King, 1998) and making connections between current schoolwork and future occupations (Greene & DeBacker, 2004).

In regard to other classroom-level factors, teacher support may be an area in which teachers may make changes to increase science achievement. Findings suggest that developing a warm learning environment through teacher support has potential for improving students’ science achievement. Deci and Ryan (1985) stated that perceived relatedness is a psychological need that increases satisfaction and motivation in a given domain. Therefore, teachers are recommended to become more aware of the importance of creating a warm classroom climate in which students feel cared for and accepted. As evidenced by the results of this study, providing a warm and supportive learning environment may be more influential on student outcomes than teachers’ background characteristics.

In terms of the instructional variables, the effect of science inquiry on achievement in Singapore was positive and in Australia and the USA it was negative compared to...
other countries. In other words, in Australia and the USA, classrooms whose teachers placed more emphasis on science inquiry scored significantly lower than their counterparts who were exposed to less science inquiry. However, these results should be taken cautiously. First, the construct of science inquiry in this study was based on the definition of inquiry specified by the TIMSS 2003. Some of the items such as “we watch teacher do science experiment” may not be consistent with the nature of science inquiry as defined by the National Science Education Standards (NRC, 1996). The standards describe science inquiry as a hands-on, minds-on process with the active involvement of students; therefore, activities such as watching teachers conduct experiments or providing scientific explanations may not meet this definition of inquiry.

Furthermore, it should be kept in mind that the TIMSS instructional variables report breadth rather than depth. Virtually all of them indicate how often certain instructional methods are used. Clearly, measuring how often any given method is used does not tell how well that method is implemented. Some researchers suggest that it is difficult to capture instructional processes through questionnaires (Burnstein et al., 1995; Rowan, Correnti, & Miller, 2002). In that sense, even though students reported high frequencies of experiencing certain instructional methods, it does not necessarily equate to how effectively or appropriately the methods were being utilized.

Another explanation for this finding could be that the science inquiry activities in the USA and Australia may not have the same impact on all children. In a recent study, Connor and colleagues (forthcoming) proposed that science instruction could be more effective when it is individualized based on students’ background knowledge and language skills. Experimental studies are needed to investigate the impact of inquiry-based activities on students’ science achievement.

Conclusions

Overall, the results of this study showed that selected student background characteristics were consistently related to elementary science achievement in countries investigated. At the student level, higher levels of home resources and self-confidence and at the classroom level, higher levels of class mean home resources yielded higher science achievement. In general, teacher and instructional variables were minimally related to science achievement. There was evidence of positive effects of teacher support on science achievement in the USA and Singapore. Science inquiry was positively related to science achievement in Singapore but negatively related in the USA and Australia. For all the countries investigated, with the exception of Singapore, the between-class variance was much smaller than the within-class variance. Japan had the smallest variation in science achievement among classrooms which reflected the homogeneity across classrooms in this country. In an effort to explain different achievement levels in elementary science among countries, the selected student- and classroom-level variables were not adequate. Further exploration of student-level and cross-country variables is recommended.
Acknowledgements

We would like to thank Dr Carol Connor from the Florida State University and Florida Center for Reading Research for her advice and assistance in the statistical analyses of this study.

References


Rowan, B., Correnti, R., & Miller, R. J. (2002). What large-scale survey research tells us about teacher effects on student achievement: Insights from the Prospects Study of Elementary Schools. Teachers College Record, 104(8), 1525–1567.


<table>
<thead>
<tr>
<th>Variable name</th>
<th>Description</th>
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<tr>
<td><strong>Outcome</strong></td>
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<tr>
<td>SCIENCE PVs</td>
<td>Science plausible values for the TIMSS 2003 4th grade</td>
</tr>
<tr>
<td><strong>Student-level</strong></td>
<td></td>
</tr>
<tr>
<td>GENDER</td>
<td>Gender of student (1 = female, 0 = male)</td>
</tr>
<tr>
<td>SELFCON</td>
<td>Science self-confidence (the index was created by TIMSS and based on students’ responses to four statements about their science ability: (a) I usually do well in science; (b) science is more difficult for me than for many of my classmates; (c) science is not one of my strengths; and (d) I learn things quickly in science [1 = low, 2 = medium, 3 = high])</td>
</tr>
<tr>
<td>HOMERES</td>
<td>Home resources (the index was created by the authors based on students’ responses to three questions about home resources: (a) about how many books are there in your home? Do you have any of these items at your home? (b) computer, (c) study desk. (1 = low [25 or fewer books in the home and no computer and study desk], 2 = medium [all other possible combinations of responses], 3 = high [more than 100 books in the home, computer and study desk]])</td>
</tr>
<tr>
<td><strong>Classroom-level</strong></td>
<td></td>
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<tr>
<td>TEXP</td>
<td>Teacher’s experience (teacher’s response on number of years of teaching experience. Continuous variable)</td>
</tr>
<tr>
<td>TEDUC</td>
<td>Teacher’s education (1 = have master’s or doctoral degree, 0 = do not have master’s or doctoral degree)</td>
</tr>
<tr>
<td>TMAJOR</td>
<td>Teacher’s major (1 = science or math major, 0 = non-science or non-math major)</td>
</tr>
<tr>
<td>TSUPPORT</td>
<td>Teacher support (the composite score of students’ responses to the following statements: (a) teacher cares about the students; and (b) teacher wants students to do their best [1 = disagree a lot, 2 = disagree a little, 3 = agree a little, 4 = agree a lot])</td>
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<tr>
<td>SCINQ</td>
<td>Science inquiry (the composite score of students’ responses to the following statements about weekly science activities: (a) We watch teacher do science experiments; (b) We plan science experiments or investigations; (c) We do science experiments or investigations; (d) We work in groups experiments or investigations; and (e) We give explanations for something we are studying in science [1 = never, 2 = a few times a year, 3 = once or twice a month, 4 = at least once a week])</td>
</tr>
<tr>
<td>SCIMIN</td>
<td>Minutes of weekly science instruction (teacher’s response to how many minutes are spent in science instruction weekly. Continuous variable)</td>
</tr>
<tr>
<td>CLASSIZE</td>
<td>Class size (teacher’s response to how many students are in class for science instruction [1 = 1–19 students, 2 = 20–26 students, 3 = 27–32 students, 4 = more than 33 students])</td>
</tr>
<tr>
<td>M_SELFCON</td>
<td>Class mean of science self-confidence (mean value of students’ self-confidence in science for each classroom)</td>
</tr>
<tr>
<td>M_HOMERES</td>
<td>Class mean of home resources (mean value of students’ home resources for each classroom)</td>
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</tbody>
</table>
Table A2. Descriptive statistics of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Singapore</th>
<th>Japan</th>
<th>USA</th>
<th>Australia</th>
<th>Scotland</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean, SD</td>
<td>Mean, SD</td>
<td>Mean, SD</td>
<td>Mean, SD</td>
<td>Mean, SD</td>
</tr>
<tr>
<td><strong>Student-level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science achievement (Average of five PVs)</td>
<td>564.57, 80.34</td>
<td>544.05, 68.15</td>
<td>530.50, 75.93</td>
<td>525.73, 74.62</td>
<td>510.02, 72.11</td>
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<tr>
<td>Gender</td>
<td>0.50, 0.50</td>
<td>0.49, 0.50</td>
<td>0.50, 0.50</td>
<td>0.51, 0.50</td>
<td>0.51, 0.50</td>
</tr>
<tr>
<td>Self-confidence</td>
<td>2.05, 0.77</td>
<td>2.33, 0.69</td>
<td>2.56, 0.64</td>
<td>2.61, 0.61</td>
<td>2.48, 0.70</td>
</tr>
<tr>
<td>Home resources</td>
<td>2.22, 0.45</td>
<td>2.16, 0.40</td>
<td>2.22, 0.47</td>
<td>2.40, 0.51</td>
<td>2.30, 0.50</td>
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<td><strong>Classroom-level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher’s experience</td>
<td>10.82, 12.66</td>
<td>20.21, 9.38</td>
<td>13.23, 10.36</td>
<td>16.46, 9.89</td>
<td>15.36, 10.29</td>
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<td>Teacher’s education</td>
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<td>0.03, 0.18</td>
<td>0.53, 0.50</td>
<td>0.26, 0.44</td>
<td>0.12, 0.32</td>
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<td>Teacher’s major</td>
<td>0.50, 0.50</td>
<td>0.20, 0.40</td>
<td>0.15, 0.36</td>
<td>0.21, 0.41</td>
<td>0.13, 0.34</td>
</tr>
<tr>
<td>Teacher support</td>
<td>7.51, 0.32</td>
<td>6.84, 0.44</td>
<td>7.65, 0.31</td>
<td>7.55, 0.34</td>
<td>7.58, 0.36</td>
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<tr>
<td>Science inquiry</td>
<td>13.47, 1.58</td>
<td>16.07, 1.13</td>
<td>13.53, 1.95</td>
<td>13.52, 2.20</td>
<td>13.65, 2.09</td>
</tr>
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<td>Minutes of science instruction</td>
<td>123.00, 14.88</td>
<td>120.48, 19.36</td>
<td>137.00, 68.86</td>
<td>71.58, 39.52</td>
<td>88.36, 56.34</td>
</tr>
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<td>Class size</td>
<td>3.88, 0.45</td>
<td>3.26, 0.93</td>
<td>2.00, 0.75</td>
<td>2.37, 0.76</td>
<td>2.50, 0.83</td>
</tr>
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<td>Class mean self-confidence</td>
<td>2.06, 0.20</td>
<td>2.32, 0.20</td>
<td>2.56, 0.23</td>
<td>2.60, 0.21</td>
<td>2.48, 0.21</td>
</tr>
<tr>
<td>Class mean home resources</td>
<td>2.21, 0.16</td>
<td>2.16, 0.11</td>
<td>2.21, 0.19</td>
<td>2.37, 0.23</td>
<td>2.30, 0.19</td>
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