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Hierarchical Effects of School-, Classroom-, and Student-Level Factors on the Science Performance of Eighth-Grade Taiwanese Students

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This study was conducted to understand the effect of student-, classroom-, and school-level factors on the science performance of 8th-grade Taiwanese students in the Trends in International Mathematics and Science Study (TIMSS) 2011 by using multilevel analysis. A total of 5,042 students from 153 classrooms of 150 schools participated in the TIMSS 2011 study, in which they were required to complete questionnaires. A 3-level multilevel analysis was used to assess the influence of factors at 3 levels on the science performance of 8th-grade Taiwanese students. The results showed that the provision of education resources at home, teachers' level of education, and school climate were the strongest predictor of science performance at the student, classroom, and school level, respectively. It was concluded that the science performance of 8th-grade Taiwanese students is driven largely by individual factors. Classroom-level factors accounted for a smaller proportion of the total variance in science performance than did school-level factors.

Keywords: *Science performance; Hierarchical linear model; Taiwan; Trends in International Mathematics and Science Study*

Introduction

Students are distributed into classrooms, and classrooms are organized into a school. In this system, students' achievement is considerably affected not only by their

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personal characteristics but also by classroom and school factors. Therefore, both classrooms and schools influence students' learning progress and performance (Mohammadpour, 2013). Numerous studies (Kalender & Berberoglu, 2009; Kaya & Rice, 2010; Yang, 2003) have investigated the degree of influence of both individual-level (i.e. parents' educational status and home resources) and classroom-level (i.e. teachers' educational status and teaching experience) factors on students' science performance. Several other studies (Mohammadpour, 2013; Sun, Bradley, & Akers, 2012) have demonstrated the influence of both student-level (i.e. attitude toward science) and school-level (i.e. school enrollment size, school resources, and language spoken at home) factors on students' science performance. However, few studies have explored the relationships between students' science performance and individual-, classroom-, and school-level factors, especially in eight-grade Taiwanese students. These studies exhibited methodological problems, particularly difficulty in distinguishing the individual-, classroom-, and school-level factors (Raudenbush & Bryk, 2002; Sun et al., 2012). In this study, a three-level multilevel analysis was used to assess the influence of the three levels of factors on the science performance of eighth-grade Taiwanese students.

The results of the Trends in International Mathematics and Science Study (TIMSS) international science report showed that eighth-grade Taiwanese students maintained a consistently high score in science performance (Martin, Mullis, & Foy, 2008; Martin, Mullis, Foy, & Stanco, 2012; Martin, Mullis, Gonzalez, & Chrostowski, 2004; Martin et al., 2000). The average science score of the eighth-grade Taiwanese students in the TIMSS 1999 assessment was 569, which was higher than the international mean score (488). However, this score is not statistically significantly different from those of Singapore, Hungary, and the Netherlands (Martin et al., 2000). In the TIMSS 2003 and 2007, of all of the participating countries, eighth-grade Taiwanese students ranked second in science, with mean scores of 571 and 561, respectively, which were higher than the international mean scores (Martin et al., 2004, 2008). According to the reports of Mohammadpour (2013) and Martin et al. (2000), the differences among schools and classrooms in student performance are usually large in top-scoring countries.

Several studies (Borman & Dowling, 2010; Chiu, 2007; Chudgar & Luschei, 2009; Sun et al., 2012) have indicated that school factors play crucial roles in students' science performance. For example, Sun et al. (2012) used a multilevel model to investigate both student and school factors that affect the science performance of secondary school students. The results showed that the school-level differences in science performance be explained by school factors. In addition, Chiu (2007) indicated that school-level differences accounted for approximately one-fourth of the total variance in science performance. Thus, school plays a vital role in students' learning process.

Previous studies have not clearly described the degree to which classroom- and school-level differences account for the total variance in the science performance of eighth-grade Taiwanese students. Martin et al. (2000) reported that students' average science performance was moderately uniform among schools, with less than 10% of the total variance in science performance attributable to differences between average school scores in Cyprus, Iceland, Japan, Korea, Norway, and Slovenia. By contrast, 40% or more of the total variance was attributable to school-level differences in Germany, Romania, Singapore, and the USA (Martin et al., 2000). Students are distributed into classrooms, and classrooms are organized into a school. Therefore, the relationship between factors and student performance is a multilevel relationship. Although previous studies have concurred that schools contribute to student performance, the influences of the classroom and the school have rarely been discussed. In the previous studies, researchers often used students as Level 1 and classrooms or schools as Level 2 in their studies. Some studies have even combined classrooms and schools as Level 2. However, the influences of classroom and school factors on student performance cannot be separated. Whether classroom factors or school factors account for more of the variance in the science performance of eighth-grade Taiwanese students must be addressed.

Student-Level Factors (Predictors)

The relationship between students' affective factors, especially science self-concept, and science performance has been extensively explored and recognized in previous studies (Chang & Cheng, 2008; Guay, Ratelle, Roy, & Litalien, 2010; Ireson & Hallam, 2009; Kaya & Rice, 2010; Thomson, 2008; Wang, Oliver, & Staver, 2008). Chang and Cheng (2008) reported that, in Taiwanese students, a statistically significant positive correlation existed between students' science performance and their self-concept and interest in science with a moderate effect size. In addition, Thomson (2008) indicated that a higher level of self-confidence in science facilitates achieving a higher science score for both male and female students. Kaya and Rice (2010) evidenced that students' self-confidence is a positive predictor of science scores. Similarly, Guay, Marsh, and Boivin (2003) indicated that self-concept is a crucial predictor of science performance.

Previous literature has reported that a positive attitude toward science is associated with science performance (Akpinar, Yildiz, Tatar, & Ergin, 2009; Hong, 2010; Hong & Lin, 2011; Martin et al., 2008; Mohammadpour, 2013). Mohammadpour (2013) and Martin et al. (2008) have reported that students who have a more positive attitude toward science achieve higher scores in science than do those with a less positive attitude. Hong (2010) observed that almost all Taiwanese students examined in her study showed interest and a positive attitude toward science.

The difference in science performance between male and female students has been extensively explored in previous studies (Akpinar et al., 2009; Hong & Lin, 2011; Liu, Lee, & Linn, 2010; Mohammadpour, 2013; Tsai, Yang, & Chang, in press). Regarding differences in mean scores, Mohammadpour (2013) used TIMSS 2007 results to show that female eighth-grade students had significantly higher science performance scores than their male counterparts did. However, Chiu (2005) reported that there was no significant difference in science performance scores between eighth-grade Taiwanese male and female students.

The influence of students' socioeconomic status (i.e. parental educational level and home resources) on science performance has been widely discussed (Kalender & Berberoglu, 2009; Myrberg & Rosén, 2006; 2008; Tsai et al., in press). Senler and Sungur (2009) demonstrated that the parental educational level has a positive relationship with students' science performance. Campbell, Hombo, and Mazzeo (2000) observed that students who have parents with a higher education level tended to have higher assessment scores. Mohammadpour (2013) reported that students from families that can provide more educational resources tend to perform more favorably in science than do those from families that cannot.

Classroom-Level Factors (Predictors)

The difference in students' achievement between schools is mainly attributable to teachers (Darling-Hammond, 2000; Lamb & Fullarton, 2002; Mohammadpour, 2013). A teacher is a key member of the classroom and plays a vital role in students' learning progress (Kaya & Rice, 2010; Mohammadpour, 2013; Rivkin, Hanushek, & Kain, 2005). Kaya and Rice (2010) indicated that a teacher is a crucial actor increasing students' interest and self-confidence in the subject matter. When a teacher becomes more passive, students might lose their interest and self-confidence (Kaya & Rice, 2010). Previous studies have reported that students were more successful in science when teachers had more years of teaching experience (Greenwald, Hedges, & Laine, 1996; Kaya, & Rice, 2010) and majored in science (Darling-Hammond, 2000; Goldhaber & Brewer, 2000). Some studies have indicated no relationship between students' performance and teachers' teaching experience or level of education (Croninger, Rice, Rathbun, & Nishio, 2007; Goldhaber & Brewer, 2000; Mohammadpour, 2013; Xu & Gulosino, 2006).

School-Level Factor (Predictors)

The school climate has been widely recognized as a vital predictor of students' performance (Van Horn, 2003). Teaching and learning may occur at any place and by using any means (e.g. mobile phone, TV, teacher), but the school is still the most crucial place for students to learn (Mohammadpour, 2013). Van Horn (2003) indicated that a positive school climate is related to students' performance. Cohen, McCabe, Michelli, and Pickeral (2009) observed that a positive school climate is associated with and predictive of academic achievement, school success, effective violence prevention, healthy student development, and teacher retention. In addition, some research (i.e. Hoy, Sweetland, & Smith, 2002; Marks, 2010; Phillips, 1997) also reported that school academic press, as a school climate indicator, had a positive effect on student achievement.

The good attendance at school (GAS) index is another indicator that is used to predict students' performance (Martin et al., 2008; Mohammadpour, 2013; Mullis, Martin, & Foy, 2008). The GAS index is measured according to students' attendance behavior, including arriving late at school, skipping classes, and being absent (Olson, Martin, & Mullis, 2008). Martin et al. (2008) reported that average science achievement was the highest among students attending schools that had few attendance problems, whereas it was the lowest among those who attended schools that had severe problems such as students arriving late and missing classes. The average science achievement for eighth-grade Taiwanese students was the highest (563 points) among those who had few attendance problems (high level of the GAS index), followed by those who had medium-level (561 points) and low-level attendance indices (545 points); thus, students attending schools at which many students arrive late, are absent, or skip classes may encounter severe problems (Martin et al., 2008).

Research Purposes

This study used hierarchical linear modeling (HLM) to investigate factors that affect the science performance of eighth-grade Taiwanese students. HLM is the most comprehensive statistical technique for analyzing hierarchical structures (Sun et al., 2012). Through this approach, the factors that affect science performance were examined at the student, classroom, and school levels. Four questions are addressed in this article:

(a) On the basis of the TIMSS 2011 results, to what degree do student-, classroom-, and school-level factors account for the variance in the science performance of eighth-grade Taiwanese students?
(b) On the basis of the TIMSS 2011 results, which student-level factors, namely attitude toward science, gender, language spoken at home, science self-concept, and home education resources, are significantly related to the science performance of eighth-grade Taiwanese students?
(c) On the basis of the TIMSS 2011 results, which classroom-level factors, namely the teachers' gender, experience, education, and major, are significantly related to the science performance of eighth-grade Taiwanese students?
(d) On the basis of the TIMSS 2011 results, which school-level factors, namely school resources, high attendance in school, and the principal's perception of the school climate, are significantly related to the science performance of eighth-grade Taiwanese students?

Methods

Participants

This study was based on a TIMSS 2011 secondary data analysis that was conducted by the IEA (International Association for the Evaluation of Educational Achievement). The sample in this study comprised 5,042 eighth-grade Taiwanese students from 153 classrooms of 150 schools that participated in the TIMSS 2011.

Measures

This section briefly describes the variables that were used in this study. Five plausible values were used to assess the students' science performance in this study. Student achievement scores were represented by random draws from achievement-score distributions, the parameters of which were estimated on the basis of the students' responses to achievement items and their background data. To eliminate the uncertainty attributable to the imputation process, each student provided five plausible values of science performance (Martin et al., 2000). At the student level, data on the students' gender, science self-concept, attitude toward science, language spoken at home, and home educational resources were derived from the student's questionnaire. At the classroom level, four observed variables were used in the study, namely, teachers' gender, teaching experience, level of education, and major. At the school level, data on the school climate, school resources, and attendance at school were derived from the school principal's questionnaire. Table 1 shows the list of all variables used along with their coding.

Data Analysis

Educational observations typically involve nested data structures in which students are nested within classrooms, and classrooms are nested within schools. Therefore, ignoring the influences from any level of the hierarchical structure may cause statistical and interpretational problems (Hox, 2002; Raudenbush & Bryk, 2002). Multilevel models are required for evaluating these multilevel influences (Hox, 2002).

In the current study, three-level HLM analyses were conducted; in these analyses, students were considered Level 1, classrooms were Level 2, and schools were Level 3. Therefore, all student-level variables were aggregated to the classroom level by averaging the data from all students within each classroom, and the variables were then aggregated to the school level by averaging the data from all students within each school (Mohammadpour, 2013). The analysis was performed using the four-step approach for multilevel modeling. In the first step, the analysis produced an unconditional model (null model) with no predictors at all three levels. This model provided a measure of the proportions of the variance in science performance within and between classrooms and schools. In the second step (Model 1), student-level predictors were added to the null model to determine whether their relationship with science performance varied significantly. In the third and the fourth steps, classroom- and school-related variables were added to the model to construct Model 2 and Model 3, respectively. Finally (full model), all three-level variables were added to the model.

In this study, five plausible values were used as dependent variables. A multiple-imputation HLM procedure was used in which results from the analysis with five plausible values were combined with the estimated parameters of the correlates of science performance (Kaya & Rice, 2010). Mean imputation was used to account for the missing data. To avoid the bias associated with inferring population

Table 1. Coding of all used variables

Variables name	Variable description
Student-level factors	
Science self-concept	(a) I usually do well in science; (b) science is not one of my strengths; (c) Science is more difficult for me; (d) I learn things quickly in science Average is computed across the items based on a four-point scale: (1) disagree a lot; (2) disagree a little; (3) agree a little; (4) agree a lot
Attitude toward science	(a) I enjoy learning science; (b) science is boring; (c) I like science Average is computed across the items based on a four-point scale: (1) disagree a lot; (2) disagree a little; (3) agree a little; (4) agree a lot
Gender	1 = girls; 2 = boys
Language spoken at home	How often do you speak the language of the test at home? (1 = never; 2 = sometimes; 3 = almost always; 4 = always)
Home educational resources	Many resources corresponding to more than 100 books in the home, having both their own room and an Internet connection, and at least one parent having completed university, on average. Few resources correspond, on average, to having 25 or fewer books, neither home study support, and neither parent having gone beyond upper secondary school. All other students were assigned to the some resources category (Martin et al., 2012) 1 = few resources; 2 = some resources; 3 = many resources
Classroom-level factors	
Teacher's gender	1 = female; 2 = male
Teaching experience	By the end of this school year, how many years will you have been teaching altogether?
Teacher's level of education	1 = did not complete upper secondary; 2 = upper secondary; 3 = postsecondary but no tertiary; 4 = diploma but not in education; 5 = first degree; 6 = second degree or higher
Teacher's major	During your <post-secondary> education, what was your major or main area(s) of study? 1 = other subjects; 2 = science education or science
School-level factors	
School principal's perception of school climate (school climate)	How would you characterize each of the following within your school? (a) teachers' job satisfaction; (b) teachers' understanding of the school's curricular goals; (c) teachers' degree of success in implementing the school's curriculum; (d) teachers' expectations for student achievement; (e) parental support for student achievement; (f) parental involvement in school activities; (g) students' regard for school property; (h) students' desire to do well in school

(*Continued*)

Table 1. Continued

Variables name	Variable description
	Average is computed across the items based on a five-point scale: (1) very low; (2) low; (3) medium; (4) high; (5) very high
School resources for science instruction (school resources)	How much is your school's capacity to provide instruction affected by a shortage or inadequacy of the following? (a) Teacher with a specialization in science; (b) computers for science instruction; (c) computer software for science instruction; (d) library materials relevant to science instruction; (e) audiovisual resources for science instruction; (f) calculators for science instruction; (g) science equipment and materials
	Average is computed across the items based on a four-point scale: (1) not at all; (2) a little; (3) some; (4) a lot
GAS	To what degree is each of the following a problem among <eighth-grade> students in your school? (a) Arriving late at school; (b) absenteeism (i.e. unjustified absences); (c) classroom disturbance
	Average is computed across the items based on a four-point scale: (1) serious problem; (2) moderate problem; (3) minor problem; (4) not a problem

characteristics, student sampling weight, science teacher weight, and school weight were used at Levels 1, 2, and 3, respectively (Mohammadpour, 2013; Tsai et al., in press).

Results

Table 2 presents the descriptive statistics on science performance according to student- and classroom-level variables. A total of 2,448 (48.43%) female and 2,594 (51.57%) male students were recruited for this survey, and their science performance was almost the same. Approximately 55% of the students spoke the language of the test at home. The increases in the mean science scores related to a 1-point increase in the language of the test being spoken at home were approximately 43, 67, and 4 points. Similarly, the increases in the mean science scores related to a 1-point increase in home education resources were approximately 66 and 57 points. Approximately 61% of the science teachers were male. Classrooms with a science teacher who had a second degree (master's degree) or higher education level had higher mean scores than did those with a science teacher who had only a first degree (bachelor's degree). Despite the fact that approximately 62% of science teachers did not have a major in science education or science, their students had higher mean science scores than did the students whose teacher did not major science education or science.

Table 2. Descriptive statistics of the science performance by students and teachers

Variables name	*N* of case (%)	Mean score	Standard deviation
Student-level factor			
Gender			
Girl	2,448 (48.43)	563.69	78.49
Boy	2,594 (51.57)	563.91	88.18
Language spoken at home			
Always	2,791 (54.86)	571.21	79.83
Almost always	1,868 (37.18)	567.24	81.12
Sometimes	349 (7.30)	500.68	88.59
Never	32 (0.66)	457.21	102.78
Home education resources			
Many resource	786 (14.70)	620.51	70.25
Some resource	3,669 (73.21)	563.55	78.01
Few resource	579 (12.09)	497.89	81.03
Classroom-level factor			
Teachers' gender			
Female	59 (38.56)	567.53	84.88
Male	94 (61.44)	561.38	82.72
Teachers' level of education			
First degree	75 (49.02)	558.95	84.72
Second degree or higher	78 (50.98)	568.51	82.27
Teachers' major (science education or science)			
Yes	58 (37.91)	560.67	84.31
No	95 (62.09)	565.68	93.17

Student-Level Influence

To address the first research question, the unconditional model was established and the results are shown in Table 3. The total variance in science performance according to the unconditional model consists of three components, the variance of student, classroom, and school, which had the values $\sigma^2 = 5506.28$, $\tau_\pi = 67.64$, and $\tau_\beta = 1434.09$, respectively. The proportions of the variance (intraclass correlation, ICC) in science performance within classroom, between classrooms, and among schools were calculated as follows:

Within-classroom difference

$$\frac{\sigma^2}{(\sigma^2 + \tau_\pi + \tau_\beta)} = \frac{5506.28}{(5506.28 + 67.64 + 1434.09)} = 0.785.$$

Classroom-level ICC

$$\frac{\tau_\pi}{(\sigma^2 + \tau_\pi + \tau_\beta)} = \frac{67.64}{(5506.28 + 67.64 + 1434.09)} = 0.010.$$

Table 3. Effects of individual-, teacher-, and school-level factors on science performance

	Null model	Model 1	Model 2	Model 3	Full model
Intercept	553.08**	557.91**	557.76**	557.16**	557.34**
	(5.48)	(5.45)	(4.59)	(4.18)	(4.00)
Student-level factor					
Attitude toward science		30.18**			30.20**
		(1.77)			(1.78)
Gender		5.85			5.50
		(3.11)			(3.37)
Language spoken at home		16.05**			15.82**
		(2.75)			(2.78)
Science self-concept		−0.95			−0.72
		(4.22)			(4.25)
Home education resources		36.12**			33.73**
		(3.28)			(3.03)
Classroom-level factor					
Teachers' gender			−7.61		−7.17
			(9.42)		(7.07)
Teachers' experience			0.86		0.38
			(0.58)		(0.45)
Teachers' level of education			20.98*		13.49
			(9.87)		(9.63)
Teachers' major			2.33		1.79
			(7.52)		(7.43)
School-level factor					
GAS				10.29	8.84
				(8.36)	(6.94)
School resources				5.44	3.12
				(5.60)	(5.80)
School climate				41.79**	38.76**
				(6.27)	(7.17)
Variance components					
Student-level variance (σ^2)	5,506.28	4,426.28	5,504.87	5,508.27	4,421.93
Classroom-level variance (τ_π)	67.64	67.64	27.83	97.08	43.85
School-level variance (τ_β)	1,434.09	648.99	1,307.56	1,008.89	1,029.76

*$p < .05$.

**$p < .001$.

School-level ICC

$$\frac{\tau_\beta}{(\sigma^2 + \tau_\pi + \tau_\beta)} = \frac{1434.09}{(5506.28 + 67.64 + 1434.09)} = 0.205.$$

The results indicated that student-, classroom-, and school-level differences accounted for 78.5%, 1.0%, and 20.5% of the total variance in science performance, respectively.

The second question concerned the effects of the selected student-level factors on eighth-grade science performance. According to Model 1, the variance in science performance attributable to classrooms and schools was 1.3% and 12.62%, respectively. The average scores were significantly different according to attitude toward science, language spoken at home, and home education resources. An increase by 1 point in the attitude toward science scale increased science performance by 30.18 points. This indicated that the average score of students who enjoyed learning science or liked science was approximately 30 points higher than those who did not. Likewise, an increase by 1 point in the language of the test being spoken at home increased science performance by 16.05 points. However, the provision of education resources at home was the strongest factor associated with science performance. An increase by 1 point in the home education resources scale increased science performance by 36.12 points. By contrast, Model 1 did not show any significant differences in science performance according to gender and self-confidence.

Classroom-Level Influence

The third research question concerned the effects of the selected classroom-level factors on eighth-grade science performance. Model 3 was constructed using only the teacher variables, namely teachers' gender, teaching experience, level of education, and major. Table 2 shows the results, which indicated that student-, classroom-, and school-level differences accounted for 80.5%, 0.4%, and 19.1% of the total variance in science performance, respectively. In general, there were no significant associations between science performance and the teachers' gender, experience, and major. A positive association between the teachers' level of education and students' science performance was observed. A 1-point increase in the teachers' education increased the average performance by approximately 21 points.

School-Level Influence

In response to the fourth research question, Model 2 was constructed using school variables, namely the GAS index, school resources, and the school principal's perception of the school climate. Table 2 shows the results, which indicated that student-, classroom-, and school-level differences accounted for 83.3%, 1.5%, and 15.2% of the total variance in science performance, respectively. The school principal's perception of the school climate positively affected eighth-grade Taiwanese students' science performance. The average increase in science performance associated with a 1-point increase in the school principal's perception of the school climate was 41.79 points.

School resources and the GAS had no statistically significant association with eighth-grade Taiwanese students' science performance. To assess the relationships among all factors from the three levels, all variables were added to the model simultaneously. The results revealed that student-, classroom-, and school-level differences accounted for 80.5%, 0.8%, and 18.7% of the total variance in science performance, respectively.

Discussion and Conclusion

A three-level multilevel analysis was performed to assess the influence of student-, classroom-, and school-level factors on the science performance of eighth-grade Taiwanese students. The results indicated that the maximum variance in science performance between students was approximately 80%. The classroom-level variance was smaller than the school-level variance (approximately 15%). In addition, the results showed a large variance in students' science performance between classrooms and schools. At the student level, higher levels of attitude toward science, home education resources, and the language of the test being spoken at home resulted in higher science performance according to the TIMSS 2011. The teachers' level of education at the classroom level and school principal's perception of the school climate at the school level were the strongest predictors of science performance.

Attitude toward science, home education resources, and the language of the test being spoken at home had significant positive effects on science performance. These findings support those of previous studies (Akpinar et al., 2009; Chang & Cheng, 2008; Kaya & Rice, 2010; Mohammadpour, 2013). Therefore, students who have an attitude toward science that is more positive, have more home education resources, and speak the language of the test at home achieve higher science scores than other students do. Family is a key factor affecting children's academic achievement. Home education resources represent the socioeconomic status or economic level. Parents can provide sufficient educational resources for children if their socioeconomic status is high. Furthermore, family factors have an obvious long-term impact on student performance. From birth until graduation, the influence lasts for more than a decade. The current study proved that the family provision of educational resources throughout the study stage exerts a major impact on science performance. According to gender, the results showed no significant effects on science performance. However, this result is not consistent with previous literature, which indicated that gender influences the science performance of Taiwanese students (Hong & Lin, 2011; Liu et al., 2010; Tsai et al., in press). The sample size and the method of analysis of the aforementioned studies were not the same as those used in the current study, potentially causing the inconsistency among the findings. However, this result is consistent with the TIMSS 2011 science report.

In addition, science self-concept had no significant association with individual students' science performance. This is not consistent with earlier research findings (Chang & Cheng, 2008; Kaya & Rice, 2010; Thomson, 2008). To improve students' science self-concept, Britner and Pajares (2006) and Kaya and Rice (2010) recommended that teachers design science activities by accommodating students' needs and abilities and providing them with stimulating tasks and materials. Teachers can help students develop efficacy beliefs through effective modeling (Kaya & Rice, 2010).

Regarding classroom-level factors, teachers' level of education is a significant predictor of science performance. This finding can facilitate encouraging teachers to take a refresher course or to increase their education level, which might play a vital role in improving the students' science performance. New knowledge or a new understanding of fundamental science concepts could help teachers creatively design lessons (Liu et al., 2010; Schneider & Krajcik, 2002). New curriculum design could, therefore, be an effective method for professional development, because student learning depends on teachers' knowledge of the curriculum (Liu et al., 2010). By contrast, teachers' gender, teaching experience, and major were not significantly related to science performance. The finding regarding gender was consistent with that of Mohammadpour (2013), who indicated that the teacher's gender is not a factor influencing science performance. Similarly, the number of teaching years did not significantly predict students' science performance. Liu et al. (2010) reported that the effect of teaching experience on student learning is mixed. Students can more clearly understand curricula through effective interpretation by experienced teachers who have a pedagogical advantage. However, experienced teachers may experience conflicts between new curricula and existing beliefs and practices. Therefore, educational reform programs must help teachers distinguish their existing beliefs from new practices and provide evidence to support the value of new directions (Liu et al., 2010).

Three school-level factors, the GAS index, school resources, and the school principal's perception of the school climate, were examined in this study. School climate was the only significant predictor of the science performance of a school. The findings support that a positive learning environment is more important than having resources for science instruction. Kaya and Rice (2010) reported that the provision of a positive and supportive learning environment may influence student science achievement more than teachers' background characteristics do. Therefore, teachers and principals are recommended to create a positive environment in which students and their parents are involved in school activities.

The findings of this study are in agreement with previous findings and provide further evidences in support of the relationships between student-, classroom-, and school-level factors and science performance. At the student level, the provision of education resources at home was the strongest predictor of science performance. At the classroom and school levels, teachers' level of education and the school principal's perception of the school climate were the strongest predictors of science performance, respectively. In addition, it was concluded that the science performance of eighth-grade Taiwanese students is driven largely by individual factors. The total variance in science performance accounted for by the classroom-level factor is smaller than that accounted for by the school-level factors.

Disclosure statement

No potential conflict of interest was reported by the authors

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