

**Comparison of Effect Size of Social and Cultural Status (ESCS) on Literacy in Various Subject Areas and Different Grades at School and Student Levels--Multilevel Analysis of 2006 PISA data for Taiwan**

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## ABSTRACT

The purpose of the study is to investigate the differences of the effects of socio-economic status (SES) on literacy in different subject areas for compulsory and non-compulsory education programs at the school and student levels. The goal was achieved by comparing the SES effects on PISA 2006 Scientific, Reading and Mathematical Literacy for grades 9 and 10 at the school and student levels. The modal grades for 15-year-olds are the 9<sup>th</sup> and 10<sup>th</sup> grades. Grade 9 is in compulsory education program while Grade 10 is not.

The independent variables included grade and subject areas. The dependent variables examined under each of the experiment conditions yielded by the independent variables included intra-class correlation coefficient (ICC), effect size of PISA index of economic, social and cultural status (ESCS) on literacy at the student and school levels, and effect size of book possession at home (BKPOSS) on literacy at the student and school levels.

Two-level hierarchical linear modeling (HLM) was implemented within each experimental condition to answer the research questions proposed in this study. The results showed that the differences in ICC across subject areas were similar, but the pattern of subject difference did not generalize over grades. At both grades, ESCS generated the greatest effect size on mathematics while the smallest on reading at the school level. However, the effect size of ESCS decreased from grade 9 to grade 10 in mathematics and reading whereas that increased in science. Book possession at home yielded the greatest effect size on science while the smallest on reading at the school level. This pattern generalized across grades. Additionally, its effect size increased from grade 9 to grade 10 in all subject areas. It was noted that the magnitudes of the effect sizes of ESCS and book possession at home were very small at the student level. Based on the difference observed over grades, a suggestion was derived that separate analyses might be necessary for compulsory and non-compulsory education programs.

Finally, an important finding was that the impact of book possession at home was greater than that of ESCS on literacy acquisition in Taiwan. The major implication obtained from this study was that compared to applying the integrated index (ESCS), using a single variable (book possession at home) for prediction appears to be an efficient approach to predicting student performance, in spite that book possession at home may be limited to describe a student's overall SES.

Keywords: socioeconomic status (SES), PISA index of economic, social and cultural status (ESCS), book possession at home, intraclass correlation (ICC), hierarchical linear modeling (HLM)

## 摘要

本研究的目的是檢核社經地位對不同學科素養的關係（或效應）組型是否隨著學生年級是義務教育或非義務教育階段而不同。為達成此目的，本研究將以多階層分析法，進行 2006 年 PISA 學生素養國際評比資料學生及學校階層分析，比較社經地位在不同就學階段對不同科目素養的解釋力。PISA 包含的科目有數學、閱讀、及科學，目標受測者為 15 歲就學學生，而 15 歲就學學生主要就讀於高中年級和國中三年級，這兩個年級分別屬於非義務教育和義務教育階段。

本研究主要的自變項包括年級和科目，依變項包括組內相關係數(ICC), PISA 經濟社會文化指標(ESCS) 在學校及學生階層對素養的效果量, 及藏書量在學校及學生階層對素養的效果量。在各研究情境中，進行二層次的階層線性模式(HLM) 分析，以解答本研究所提出的研究問題。研究結果顯示，在不同年級，ICC 跨科目的差異是類似的但組型無法在年級間類推。

在學校階層，不管在哪一個年級，ESCS 對數學素養上有最大的解釋力，但在閱讀素養的解釋力最小；然而 ESCS 在數學和閱讀的效果量隨著年級的增長而減少但對科學領域卻是增加的。此外，藏書量在學校階層對科學有最大的解釋力但對閱讀的解釋力最小，此組型可在年級間類推；而且藏書量對所有科目的解釋力隨年級漸長而漸增。另外，在學生階層，ESCS 和藏書量的效果量都非常些微。依據研究結果，各科 ICC 及社經地位指標對各科素養效果量的組型似乎隨著就學階段的不同而不同，因此這些研究分析似乎有分開進行的必要，也就是義務教育階段的資料分析必須與非義務教育階段的分析分開進行。

本研究發現單一變項藏書量對學生素養的解釋力大於 PISA 的 ESCS 統整性指標，因此比起 PISA 的統整性指標，運用單一變項來預測學生素養速乎符合經濟效益原則，但如何以藏書量適切的表徵社經地位將是未來研究的核心問題。

關鍵詞：社經地位， PISA 經濟社會文化指標，藏書量，組內相關係數 (ICC)，階層線性模式

## INTRODUCTION

### **Difference between student literacy ability and academic achievement**

The concept of literacy is different from that of academic achievement. Academic achievement refers to what students know and can do in various subject areas. Academic achievement testing focuses on assessment of curriculum-based abilities. For example, the National Assessment of Educational Progress (NAEP) is the nationally representative and continuing assessment of America's student curricular achievement in various subject areas. However, literacy ability is concerned with the capacity of students to apply what they have learned in novel situations, and students' ability to analyze, reason and communicate effectively as they pose, solve and interpret problems in various settings.

The OECD Programme for International Student Assessment (PISA) is an internationally standardized assessment jointly developed by participating nations and administered to 15-year-old students. Recognizing the difference between student literacy ability and academic achievement, the PISA was developed to assess how far 15-year-olds students who are near the end of or just finish compulsory education have obtained the knowledge and skills that prepare them for full participation in society. The PISA began in 2000 and was held every three years. In each cycle, the subject areas of reading, mathematical and scientific literacy are covered, with one subject being selected as a focus while two other subjects assessed more briefly.

Forty-three countries were administered the survey with Mathematics as a focus in the 1<sup>st</sup> assessment in 2000, 41 countries were in the 2nd assessment with Science as a focus in 2003, 57 countries were in the 3rd assessment with Reading as a focus in 2006, and 62 countries would be in the 4th assessment with Mathematics again as a focus in 2009. Number of examinees typically ranges between 4,500 and 10,000 in each country.

### **Indicator of student socio-economic status (SES)**

The index of SES has been defined diversely for its lack of solid conceptual meaning in literature. Many studies adapted a definition of SES conforming to that developed by Duncan, Featherman and Duncan (1972), SES being indicated by parents' education levels, parents' occupations, and family income as a whole (Gottfried, 1985; Hauser, 1994; Mueller & Parcel, 1981; Willms, 2003).

Alternatively, some studies applied fathers' and mothers' socioeconomic characteristics separately to indicate students' SES, such as their education levels (Marks, 2008; Brooks-Gunn, Duncan, & Britto, 1999; Korrup, Ganzeboom, & Lippe, 2002;), occupations (Marks, 2008; Kalmijn, 1994; Korrup, Ganzeboom, & Lippe,

2002), and income (Dills, 2006; National Commission on Children, 1991). Mueller and Parcel's (1981) defined SES as an individual's or a family's rank on a hierarchical social structure based on their access to valued commodities, such as wealth, prestige and power. Some studies acknowledged family resources to education and home language as an important measure of SES (Aram & Levin, 2001; Verhoeven & Vermeer, 2006).

As no direct measure on parental income was available due to a lack of parent questionnaires, ownership of relevant household items was used as a proxy in some studies. Some researchers have seen home resources as indicators of family SES. These resources include (1) home possessions, such as books, computers and a study room; and (2) the availability of educational services after school and during summer breaks (Aram & Levin, 2001; McLoyd, 1998; Eccles, Lord, & Midgley, 1991; Entwisle & Astome, 1994).

In PISA, similar variables were chosen as indirect measure on family wealth because some countries did not take the Parent Questionnaire and thereby data of parental income was not available. The questions were categorized into three groups, cultural possessions at home, home educational resources, and availability of household possessions. Two additional indicators were specified to describe students' SES background, which were highest occupational status of parents (HISEI) and highest educational level of parents (HISCED) in years of schooling. Accordingly, PISA index of economic, social and cultural status (ESCS) was derived by integrating these five indicators introduced just now. The elements included in PISA index of ESCS will be described in detail in the Method section.

### **Relationship between student SES and academic achievement**

Many studies have revealed the profound effect size of student SES on academic achievement. Based on the review of Kesamang and Taiwo (2002), home environment has profound influence on students' achievement in school science (Peterson & Carlson, 1979; Schibeci & Riley, 1986; Taiwo et al., 1999; Taiwo & Tyolo, 2002). Additionally, socio-cultural factors is essential in science learning in non-western cultures (Jegade, 1987; Jegede and Okebukola, 1988). In general, the better reading achievement tended to be associated with high-income levels, and vice versa (e.g., Dickinson & Snow, 1987; Jantz, 1987; Nicholson & Gallienne, 1995; Pungello, Kupersmidt, Burchinal, & Patterson, 1996). Ramey and Ramey (1998) also showed that children from low-income families are more likely to have low level of reading achievement than other socioeconomic groups.

According to Sirin's (2005) review, the effect of social economic status on academic achievement may be different by students' grade level (Duncan,

Brooks-Gunn, & Klebanov, 1994; Lerner, 1991). White's (1982) review indicated that as the students progressed through the grades, the association between SES and school achievement diminishes. However, Sirin's (2005) review indicated that the association between SES and academic achievement increased across various grades, with the exception at the high school level. The explanation for this SES-academic achievement relationship provided by Sirin (2005) stated that students from lower-SES backgrounds were more likely to perform poorly in compulsory education and drop out of school later. Accordingly, they were not included in the sample in the later years of schooling.

In Taiwan, Taiwan Assessment of Student Achievement in Mathematics (TASA-MAT) was developed to collect Taiwan educational statistics in mathematics based on the new curriculum standards. Based on the data derived from 2006 TASA-MAT pilot testing for grades 4, 6, 8 and 11 (Hung, Tzou, Lin, & Lin, 2006), an interesting outcome was found that students' book possession at home demonstrated greater effect size on students' academic achievement than the other SES indicators, such as parental education level and eligibility of free lunch.

### **Relationship between student SES and literacy ability**

Several studies have also shown the significant association of student SES and literacy ability. The results from several prior studies indicated that children coming from affluent, high-SES families tend to have high verbal abilities, and have a greater chance to obtain positive development outcomes (e.g., Burgess, 1997; Chase-Lansdale, Gordon, Brooks-Gunn, & Klebanov, 1997; Klebanov, Brooks-Gunn, McCarton, & McCormick, 1998).

Brunell & Saretsalo (1999) explained that different family socio-cultural status would be associated with different resources, processes and attitudes relevant to the language, thinking, knowledge, skills and communication in the very early growth environments. As a result, children from different socio-cultural environments are socialized into different levels of literacy because they are socialized into different knowledge, different language practices and different ways of thinking.

The strong association between home learning resources and reading literacy has been confirmed in many social and education studies (Nicholson, 1999; Bradley, Corwyn, Burchinal, Pipes McAdoo, & Garcia Coll, 2001). Thorpe's (2006) study further showed that family SES has a significant influence on students' reading learning. In the UK, the social economic circumstances of students play crucial roles at both the school level and the student level. Within the same school, students from higher SES levels perform better in reading acquisition than those from lower SES levels (Thorpe, 2006).

## **Research Purpose**

The main purpose of this study is three-fold. The first is to compare the effect sizes of student SES (PISA index of ESCS) on literacy acquisition across various subject areas by grade at the student and the school levels. The other is to compare the effect sizes of student book possession at home on literacy across different subject areas by grade at the student and the school levels. Finally, the individual SES index (book possession at home) and the overall index of SES (PISA index of ESCS) were compared in terms of effect size on literacy ability in various subject areas by grade at the student and school levels. Students' book possession at home was also examined in this study because it showed substantial effect size on academic achievement in Taiwan and was anticipated to have certain impact on literacy acquisition.

The attainment of literacy is a lifelong process, and it develops not just through formal learning at school, but also through private interactions with family and wider communities. Families with high socioeconomic status often have better chance to succeed in preparing their children for learning because they would have access to abundant and variety of resources to promote and support children's development. For example, they are able to provide their children with books, to encourage children in learning activities, and to offer support in emotional and cognitive development. In addition, PISA measures the ability to solve real-life like problems, relying on a broad understanding of key concepts rather than subject-specific knowledge. Therefore, family SES is anticipated to have similar impact on literacy in various subject areas.

This study also made comparisons between grade 9 and grade 10. These two grades represent different education programs, with grade 9 from compulsory and grade 10 from non-compulsory education programs. Accordingly, it was anticipated that the effect sizes of SES indicators on literacy acquisition may be various education program.

## **Research Questions**

Based on the research purpose for this study, five research questions were derived and listed as following:

- (1) Does the effect size of PISA index of ESCS on literacy acquisition vary across mathematics, reading and science subject areas at grade 9 at the student and the school levels?
- (2) Does the effect size of PISA index of ESCS on literacy acquisition vary across mathematics, reading and science subject areas at grade 10 at the student and the school levels?
- (3) Does the pattern of difference in the effect size of ESCS across subject areas generate over grades?

- (4) Does the effect size of book possession at home on literacy acquisition vary across mathematics, reading and science subject areas at grade 9 at the student and the school levels?
- (5) Does the effect size of book possession at home on literacy acquisition vary across mathematics, reading and science subject areas at grade 10 at the student and the school levels?
- (6) Does the pattern of difference in the effect size of book possession at home across subject areas generate over grades?
- (7) Does book possession at home conform to the pattern generated by ESCS in effect size on literacy acquisition by subjects and grades?

Questions (1) through (3) correspond to the first research purpose, (4) through (6) to the second purpose, and (7) to the third purpose.

## METHOD

### Data Source

The data for this study is derived from the Taiwanese participation in the 2006 PISA study conducted by OECD. Table 1 shows the number of students and schools for Grade 9 and Grade 10 used in this study. In proportion to the student enrollment of the modal grade for fifteen-year-olds in Taiwan, approximately two third of examinees (6090 out of 8797) were sampled from the 10<sup>th</sup> grade while approximately one third (2707 out of 8797) of examinees were from the 9<sup>th</sup> grade (see Table 1). In Taiwan, Grade 9 is the last year of compulsory education, and thereby Grade 9 represents compulsory program in this study. On the other hand, Grade 10 represents non-compulsory program.

Table 1  
Number of students and schools in the current analysis

Grade	Students (%)	Schools
Grade 9 (junior high school)	2707 (31%)	89
Grade 10 (senior high school)	6090 (69%)	166
Total	8797 (100%)	236

Note: Total number of schools is less than 255=89+166 because some schools are complete high schools, which include Grade 9 and Grade 10.

## **Design**

The independent variables included subject area (mathematics vs. reading vs. science) and grade (grade 9 vs. grade 10). Primary evaluation criteria or dependent variables included intraclass correlation coefficient (ICC), effect size of ESCS on literacy at student and school levels, and effect size of book possession at home (BKPOSS) on literacy at the student and school levels. In the section to follow, the definition of ICC is described in detail. This design yielded 6 (3×2) experimental conditions for each dependent variable. To simplify the interpretation of the results, special emphasis will be placed on comparisons among subject areas across various grades.

To examine effect sizes of ESCS and book possession at home on literacy at both student and school levels, two-level Hierarchical Linear Modeling (HLM) analyses were implemented in this study. These analyses are discussed in the section that follows.

## **Two-Level HLM Analyses**

Recognizing that the PISA data are hierarchical in nature, Hierarchical Linear Modeling (HLM) (Raudenbush and Bryk, 2002) was applied in this study. Within each experimental condition, a two-level regression analysis was performed with specifying students as level one and schools as level two. Accordingly, the total sample variance was decomposed into the between-school variance and within-school variance, and the parameters in the two-level regression models were estimated by using a full maximum likelihood procedure. Under a HLM analysis, student final weights were normalized so that the sum of the weights equaled the number of students in the dataset.

In each subject area, five plausible values for the students' performance were specified as the outcome variable. To examine the effect sizes of PISA index of economic, social and cultural status (ESCS) and book possession at home (BKPOSS) on student performance individually, ESCS and BKPOSS served as the explanatory variable in their correspondent regression model at level 1, and the school average ESCS and school average BKPOSS as the explanatory variable at level 2. Table 2 outlines the multilevel models built for this study, starting from the student level (level 1) upwards to the school level (level 2).

Table 2

Unconditional and conditional models in HLM for effect of socio-economic background on student performance

Model: Explanatory variable	Model
Unconditional model: No explanatory variables were added at Level-1 and Level-2.	Level-1 Model (student level) $Y = B_0 + R$ Level-2 Model (school level) $B_0 = G_{00} + U_0$
Condition model: Student level: PISA index of economic, social and cultural status (ESCS) School level: School average PISA index of economic, social and cultural status (MEAN_ESCS)	Level-1 Model (student level) $Y = B_0 + B_1*(ESCS) + R$ Level-2 Model (school level) $B_0 = G_{00} + G_{01}*(MEAN\_ESCS) + U_0$
Condition model: Student level: book possession at home School level: School average book possession at home (MEAN_BKPOSS)	Level-1 Model (student level) $Y = B_0 + B_1*(BKPOSS) + R$ Level-2 Model (school level) $B_0 = G_{00} + G_{01}*(MEAN\_BKPOSS) + U_0$

Note:

- (1) Y represents student literacy score.
- (2) B<sub>0</sub> and B<sub>1</sub> are level-1 coefficients, which refer to intercept and regression coefficients in the model, respectively.
- (3) R represents a level-1 random effect.
- (4) G<sub>00</sub>, G<sub>10</sub> and G<sub>01</sub> are level-2 coefficients.
- (5) U<sub>0</sub> is a level-2 random effect.

Under the modeling, we assume:  $E(R)=0$ ,  $E(U_0)=0$ ,  $Var(R) = \sigma^2$  and  $Var(U_0)=\tau_0$ , where  $\sigma^2$  is the level-1 variance, and  $\tau_0$  is the level-2 variance.

Intraclass correlation coefficient (ICC) is defined as  $\rho = \frac{\tau_0}{(\tau_0 + \sigma^2)}$ , which measures the proportion of total variance in the dependent variable (Y) which is between groups (i.e., between the level-2 units).

Equity of Learning Opportunity. Therefore, given that total variance is composed of between- and within-school variances, the intraclass correlation coefficient (ICC) is defined as the proportion of total variance explained by between-school variance. The ICC could be the indicator of education equity. Lower intraclass correlations represent higher levels of equity, and vice versa.

## **Variables in HLM Analyses**

The dependent variables in the HLM analyses for this study were scale scores for mathematical, reading, and scientific literacy. The explanatory variables were the PISA index of economic, social and cultural status (ESCS), and book possession at home (BKPOSS).

The index of ESCS. To describe broader aspects of a student's home background and family occupational status, PISA integrates the economic-capital, social-capital, and cultural-capital variable sets into a general index of student SES. This general SES index was called PISA index of economic, social and cultural status. It was derived from the following indicators: cultural possessions at home (CULTPOSS), highest occupational status of parents (HISEI), highest educational level of parents (HISCED) in years of schooling, home educational resources (HEDRES), and availability of household possessions (HOMPOS), in which number of books at home (BKPOSS) was included. The scaling for ESCS was implemented by first estimating item parameters of common items separately for each country with Item Response Theory (IRT). The average of the common items' parameters was constrained to zero for each country. Afterwards, the remaining items were added with the common item parameters being fixed, and each country was scaled separately.

The index of cultural possessions at home (CULTPOSS) was obtained by asking students some questions on the ownership of classic literature, books of poetry and works of art in their home. Next, the index of home educational resources (HEDRES) was generated by asking students particular questions on the ownership of the following items in their home: (1) a desk to study at, (2) a quiet place to study, (3) a computer they can use for school work, (4) educational software, (5) their own calculator, (6) books to help with their school work, and (7) a dictionary. Scale construction for either CULTPOSS or HEDRES was implemented through IRT scaling and positive values signal higher levels of possessions.

Additionally, availability of household possessions was applied to indicate family wealth. This index was created by asking students the following three sets of questions:” i) whether students had a room of their own, a link to the Internet, a dishwasher and a DVD or VCR player; ii) how many of the following items they had at their home: cellular phones, televisions, computers and cars; and iii) three country-specific items thought to indicate wealth defined by each country” (OECD, 2006). Similarly, the scaling for this index was performed through IRT method, and positive values indicated higher levels of family wealth. For detailed information on the scaling of these indicators, please see the PISA 2000 (OECD, 2000) or PISA 2006 Technical Reports (OECD, forthcoming).

## RESULTS

In addition to displaying the results based on overall students' performance on its assessments, we show the results based on the performance of different grades of students.

Table 3 presents the mean, standard deviation (SD), minimum and maximum of students' literacy scores in the three subject areas and ESCS for the total sample, grades 9 and 10. As expected, the average scores of grade 10 were greater than those of grade 9 for all subject areas. For the total sample, the greatest disparity (SD) was found in mathematics, the medium in science, and the smallest in reading. Grades 9 and 10 conformed to this pattern. A common pattern can be observed in the SD difference over grade for all subjects. That is, the greater score disparity tended to be associated with grade 10, the non-compulsory education program. Although the mean and SD of ESCS were greater at grade 10 than at grade 9, the corresponding differences were negligible.

Table 3

Descriptive statistics of literacy scores and ESCS at the student level for 2006 PISA sample in Taiwan

Variable		Average	SD	Min	Max
Mathematics	Total	549.36	103.11	163.49	859.71
	Grade 9	538.89	96.81	190.32	813.37
	Grade 10	555.37	106.13	170.66	858.63
Reading	Total	496.24	84.39	123.67	754.75
	Grade 9	487.30	80.58	162.57	732.04
	Grade 10	501.37	86.10	131.26	753.04
Science	Total	532.47	94.45	202.35	808.66
	Grade 9	525.75	89.37	234.52	792.47
	Grade 10	536.32	97.08	202.35	808.66
ESCS	Total	-0.31	0.80	-4.16	2.34
	Grade 9	-0.33	0.79	-4.16	2.28
	Grade 10	-0.30	0.80	-4.08	2.34

Table 4 shows the mean, standard deviation (SD), minimum and maximum of literacy scores at the school level in the three subject areas and ESCS for the total sample, grades 9 and 10. Similarly, the greatest school-mean disparity (SD) was found in mathematics, the medium in science, and the smallest in reading. Besides, similar to the pattern of grade difference found at the student level, grade 10 had greater

average school mean and school-mean disparity than grade 9. It is interesting to note that the magnitude of differences was greater at the school level. Nevertheless, an exception was found in the SD of school-mean-ESCS, where school disparity in ESCS was greater at grade 9 than at grade 10. The results suggested that the school disparity in ESCS for the compulsory education program (0.49) was larger than that for senior high schools (0.42).

Table 4

Descriptive statistics of literacy scores and ESCS at the school level for 2006 PISA sample in Taiwan

Variable		Average	SD	Min	Max
Mathematics	Total	515.52	73.13	364.35	731.14
	Grade 9	510.99	57.31	402.96	681.26
	Grade 10	525.48	89.29	364.35	731.14
Reading	Total	468.07	61.59	339.04	642.12
	Grade 9	463.28	51.00	371.98	619.84
	Grade 10	477.35	72.41	339.04	642.12
Science	Total	504.22	63.78	381.87	688.57
	Grade 9	502.41	48.39	407.81	665.68
	Grade 10	510.30	79.70	381.87	688.57
ESCS	Total	-0.49	0.47	-1.61	0.72
	Grade 9	-0.53	0.49	-1.61	0.72
	Grade 10	-0.44	0.42	-1.24	0.67

### Relationships of Student Literacy in Various Subject Areas

To examine the differences of the effects of socio-economic status (SES) on Scientific, Reading and Mathematical Literacy, the analyses began with a description of correlations among the three subject areas. Table 5 shows the correlations among the literacy scores in mathematics, reading and science for the total sample, Grades 9 and 10. Similar patterns could be found in the correlations among the three subject areas for the total sample, grade 9 and grade 10. These correlations were quite high, ranging from 0.799 to 0.901. The greatest correlations were observed for mathematics and science (0.881~0.901) while the lowest correlations were found for mathematics and reading (0.799~0.822). Although differences of correlations for every two subjects were found, the magnitudes of the differences were not quite large. The outcome of these correlations appeared to sustain the concept that the literacy ability tends to be independent of subject-specific knowledge.

Table 5

Correlations among 2006 PISA mathematical, reading and scientific literacy for the total sample and by grade

	Total		Grade 9		Grade 10	
	reading	science	reading	science	reading	science
math	0.822	0.895	0.799	0.881	0.831	0.901
reading	0.868		0.859		0.873	

Note: Total sample refers to the 9<sup>th</sup>- and 10<sup>th</sup>-grade students.

### Variance Decomposition for Student Literacy and SES Indicators

The PISA data are hierarchical in nature, with students within schools. The total variance can be decomposed into two exclusive components, the within- and between-school components. HLM was applied in the two-level model estimation for this study. Using the PISA 2006 data, we estimated the two variance components for Taiwan.

Student Literacy. This analysis was first conducted with the literacy scores in mathematics, reading and science, using their corresponding five plausible values, and weighted. Table 6 provides the total variance estimates and the variance-components. The variance components were expressed as proportions of the total variance estimates in each subject at grades 9 and 10. The proportion of the total variance which was between schools was analogous to the definition of the intraclass correlation (ICC). The ICC values can both indicate the degree of homogeneity of students in the same school and the degree of heterogeneity across schools. At grade 10, the greatest ICC was found in mathematics (0.659), the medium in science (0.625), and the smallest in reading (0.604). However, grade 9 did not conform to this pattern. At grade 9, the greatest ICC was associated with reading (0.308) while the smallest with science (0.240).

Table 6

Total variance and variance components of literacy in Mathematics, Reading and Science at Grade 9 and Grade 10

Sample	Subject	Total variance	Between school (ICC)	Within school (1-ICC)
Grade 9	Mathematics	10211.500	0.282	0.718
	Reading	7492.621	0.308	0.692
	Science	8478.679	0.240	0.760
Grade 10	Mathematics	11568.120	0.659	0.341
	Reading	7880.420	0.604	0.396
	Science	9645.762	0.625	0.375

At the first glance, we noticed that grade 10 had ICC values (0.604~0.659) at least twice as high as grade 9 (0.240~0.308). The greater degree of heterogeneity in school average literacy score for senior high schools might be the result of the high-school entrance exam.

SES indicators. The HLM analysis was also conducted with student SES and weighted. PISA index of economic, social and cultural status (ESCS) was applied to measure student SES for PISA. To reveal student SES in Taiwan in detail, HLM analysis was done for each component included in PISA index of ESCS. Table 7 presents mean, standard deviation and ICC for various SES indicators under total, grade 9 and grade 10 samples. The SES indicators listed in Table 7 refers to PISA index of economic, social and cultural status (ESCS) and its components. These components include number of books at home (BKPOSS), cultural possessions at home (CULTPOSS), highest occupational status of parents (HISEI), highest educational level of parents (HISCED), home educational resources (HEDRES), and availability of household possessions (HOMPOS).

Table 7

Mean, standard deviation and ICC for SES indicators under total, grade 9 and grade 10 samples

Indicators	Total			Grade 9			Grade 10		
	Mean	SD	ICC	Mean	SD	ICC	Mean	SD	ICC
ESCS	-0.31	0.80	0.275	-0.33	0.79	0.292	-0.30	0.80	0.250
BKPOSS	3.09	1.41	0.153	3.09	1.43	0.127	3.09	1.39	0.175
CULTPOSS	0.08	0.89	0.136	0.07	0.89	0.106	0.09	0.89	0.163
HISEI	48.49	16.09	0.146	47.75	16.34	0.151	48.92	15.93	0.135
HISCED	3.87	1.28	0.202	3.86	1.28	0.227	3.88	1.29	0.160
HEDRES	-0.49	0.89	0.119	-0.54	0.88	0.111	-0.46	0.89	0.118
HOMPOS	-0.40	0.80	0.192	-0.40	0.82	0.207	-0.40	0.80	0.168

As shown in Table 7, the 9<sup>th</sup> graders appeared to have slightly lower mean SES than the 10<sup>th</sup> graders. Besides, the 10<sup>th</sup> graders tended to have smaller disparity of SES than the 9<sup>th</sup> graders with exceptions in ESCS, HISCED and HEDRES. Similarly, the 10<sup>th</sup> graders seemed to have smaller ICC of SES than the 9<sup>th</sup> graders with exceptions in BKPOSS, CULTPOSS and HEDRES. The greater school mean and lower or comparable school SD of SES for grade 10 in Taiwan might result from that students from lower-SES backgrounds were more likely to fail the high-school entrance exam and thereby not included in the sample in the later years of schooling. However, it should be noted that the differences of grades 9 and 10 were all negligible in terms of

mean, SD and ICC for all SES indicators.

### **Relationships between Student Literacy in Various Subject Areas and PISA SES Indicators**

Table 8 provides the correlations of student literacy and PISA ESCS and its components. The three subject areas had similar correlations for each SES indicators. It was noted that the indicator of book possession at home (BKPOSS) had greater correlations than PISA ESCS with student literacy in all subjects for total, grade 9 and grade 10 samples. This outcome suggested that for Taiwan, one of the PISA ESCS components, the indicator of book possession at home, might be more powerful than PISA ESCS in predicting student literacy in various subjects.

Table 8

Correlations of literacy and SES indicators under total, grade 9 and grade 10 samples

Indicators	Total			Grade 9			Grade 10		
	Math	Read	Sci	Math	Read	Sci	Math	Read	Sci
ESCS	0.360	0.360	0.354	0.368	0.369	0.368	0.355	0.356	0.347
BKPOSS	0.384	0.395	0.386	0.388	0.405	0.405	0.384	0.392	0.377
CULTPOSS	0.322	0.372	0.342	0.308	0.369	0.336	0.331	0.375	0.346
HISCEI	0.254	0.267	0.258	0.255	0.270	0.258	0.251	0.264	0.257
HISCED	0.297	0.300	0.307	0.320	0.328	0.337	0.286	0.285	0.293
HEDRES	0.266	0.263	0.238	0.288	0.284	0.260	0.251	0.249	0.225
HOMPOS	0.277	0.262	0.247	0.261	0.245	0.237	0.287	0.273	0.254

To reveal more information about whether predictive power of book possession at home is greater than ESCS in Taiwan, two-level HLM analyses were conducted in each subject area at grades 9 and 10. Table 9 displays the percentage of variance accounted for by ESCS at the student and school levels. For both grades, the greatest percentage of variance explained by ESCS was associated with mathematics (73.2% and 65.2% for grades 9 and 10, respectively), the medium with science (62.5% and 62.9% for grades 9 and 10, respectively), while the smallest with reading (62.3% and 60.6% for grades 9 and 10, respectively) at the school level. With regard to the grade difference at the school level, the percentage decreased from grade 9 to grade 10 in mathematics and reading whereas that increased in science. Similarly, the percentage decreased from grades 9 to 10 in each subject area at the student level although those percentages were very small.

Table 9

Percentage of variance explained by ESCS at the student and school Levels

Grade	Subject	Between (%)	Within (%)
Grade 9	Mathematics	73.2	5.1
	Reading	62.3	6
	Science	62.5	5.5
Grade 10	Mathematics	65.2	0.2
	Reading	60.6	0.8
	Science	62.9	0.2

Table 10 shows the percentage of variance in each subject area accounted for by book possession at home at the student and school levels. For both grades, the greatest percentage of variance explained by book possession at home was associated with science (70.9% and 78.0% for grades 9 and 10, respectively), the medium in mathematics (70.0% and 77.2% for grades 9 and 10, respectively), while the smallest with reading (63.2% and 76.8% for grades 9 and 10, respectively) at the school level. With regard to the grade difference at the school level, the percentages increased from grade 9 to grade 10 in all subject areas. On the other hand, the percentage decreased from grades 9 to 10 in each subject area at the student level although those percentages were small.

Table 10

Percentage of variance explained by book possession at home at the student and school levels

Grade	Subject	Between (%)	Within (%)
Grade 9	Mathematics	70.0	8.5
	Reading	63.2	9.5
	Science	70.9	9.3
Grade 10	Mathematics	77.2	3.0
	Reading	76.8	2.4
	Science	78.0	1.6

It is interesting to noted that greater power was observed, in Taiwan, for book possession at home than for ESCS in predicting literacy acquisition of each subject area at the student and school levels. Additionally, book possession at home had smallest predictive power for reading literacy at both grades, so did ESCS. Finally, the effect size of book possession at home increased from grade 9 to grade 10 at the school but decreased at the student level. ESCS conform to this pattern at student level but not at the school level.

## CONCUSION and DISCUSSION

As stated previously, the ICC could be the indicator of education equity. Lower intraclass correlations represent higher levels of equity, and vice versa. In this study, differences of ICC among mathematics, reading, and science, were found but not significant at grade 9 and grade 10. At grade 9, the greatest ICC was associated with reading while the smallest with science. However, grade 10 did not conform to this pattern. At grade 10, the greatest ICC was found in mathematics while the smallest in reading.

Additionally, the outcomes of this study indicated that senior high schools demonstrated higher degree of heterogeneity across schools than the compulsory education program in Taiwan. The ICCs ranged from 0.604 to 0.659 at grade 10 while ranged from 0.240 to 0.308 at grade 9, and thereby grade 10 appeared to have ICC values at least twice as high as grade 9. The grater ICCs of senior high schools is the result of the high-school entrance exam in Taiwan. Relatively speaking, the ICCs for the compulsory education program in Taiwan seemed to be smaller than the OECD averages for 2006 PISA, with mathematics yielding 0.472, reading 0.449, and science 0.462. On the contrast, the ICCs yielded by the non-compulsory education program in Taiwan were greater than the OECD averages for 2006 PISA.

Before comparing the effects of socio-economic status (SES) on scientific, reading and mathematical literacy acquisitions by grade, analysis of bivariate correlation for the three subject areas was performed. Similar to the outcome of ICCs, differences of correlations for every two subjects were found but not significant at both grades. The greatest association was observed for mathematics and science while the lowest was found for mathematics and reading, which was in line with what was found in studies relevant to academic achievement. Furthermore, three subject areas had high association among themselves in literacy acquisition. The outcomes of the correlations appeared to sustain the concept that the literacy ability tends to be independent of subject-specific knowledge.

Based on the results of two-level HLM analyses, the answers to research questions (1) ~ (3) are that the patterns of effect size of ESCS on students' performance in various subjects across grades were mixed. ESCS generated the greatest effect size on mathematics, the medium on science, while the smallest on reading at the school level. This pattern generalized across grades. However, as for the grade difference in each subject area at the school level, the effect size of ESCS decreased from grade 9 to grade 10 in mathematics and reading whereas that increased in science. The effect size of ESCS also decreased from grades 9 to 10 in each subject area at the student level but the magnitudes were very small.

With regard to the individual index of SES, book possession at home, the

patterns of its effect size on students' performance in various subjects across grades were consistent, which answers research questions (4) ~ (6). Book possession at home yielded the greatest effect size on science, the medium on mathematics, while the smallest on reading at the school level. This pattern generalized across grades. Additionally, its effect size increased from grade 9 to grade 10 in all subject areas. Conforming to the pattern generated by ESCS, the effect size of book possession at home decreased from grades 9 to 10 in each subject area at the student level but the magnitudes were very small.

This study yielded an important finding, meanwhile answering research question (7). Evidence derived from 2006 PISA data showed that the impact of book possession at home was greater than that of PISA index of ESCS in Taiwan. One possible reason would be that book possession at home was a direct and valid indicator of student socioeconomic status, and an indirect but valid measure on parental income in Taiwan. Alternatively, PISA index of ESCS includes not only students' possession at home but also parental socioeconomic characteristics. Additionally, students' ESCS scores were derived through factor analysis with a Principal Component Analysis (OECD, 2006). As a result, for Taiwan, the predictive power of an overall index of SES such of ESCS on literacy acquisition appeared to diminish within the integrated process.

A message from this finding would be that the single variable, book possession at home, might be sufficient and powerful enough in predicting student literacy acquisition in Taiwan. Compared to applying the integrated index (ESCS), using a single variable for prediction appears to be an efficient approach to predicting student performance, in spite that book possession at home may be limited to describe a student's overall SES. More studies may need to be conducted to verify this anticipation.

Another implication from this study was that conducting analyses and interpreting results separately for compulsory and non-compulsory education programs appeared to be necessary. This suggestion was mainly based on the results of differences and mixed patterns in ICC and effect size of the SES indicators over the two programs.

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