

Singapore Grade 8 Students' Performance in Science by Gender in TIMSS 2007

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Abstract

The international databases for TIMSS 2003 and TIMSS 2007 were used to analyze gender-related data for Singapore in science at grade 8 level. In this analysis, we looked into the overall performance in science of the students and their performance by gender within content domains and cognitive domains at grade 8. Furthermore, we looked into how the teacher's gender impacted on the students' performance using SAS. Students' self-confidence was also examined from a gender perspective. This brief overview of the gender-related data about performance in science of students from Singapore demonstrates that female students in Singapore are doing fairly well when compared to their male counterparts. Although the overall data might not show any significant differences, there exist some differences when the content and cognitive domains are examined more closely. Regarding different teacher-student groupings, some groupings like *male teacher-male student* seemed to be less effective.

Keywords: *TIMSS 2003, TIMSS 2007, gender, science*

Introduction

In this study we look at the gender-related data from the Trends in International Mathematics and Science Study 2007 (TIMSS 2007) for Singapore students in Science at grade 8 level. When gender equality became one of the eight United Nations Millennium Development Goals in 2000, there was a renewed interest in gender issues in education. As such, gender has emerged internationally as a social and political issue (Adams, 2002). In our analysis, we consider gender as concerning both males and females rather than focusing on only one specific gender.

Methodology

We used the international databases for TIMSS 2003 and TIMSS 2007 (see Martin, 2005; Foy & Olson, 2009). TIMSS 2003 data were used to provide for comparison of the data from TIMSS 2007. In our analysis, we looked into the overall performance in science of the students and their performance by gender within content domains and cognitive domains at grade 8. Furthermore, we looked into how the teacher's gender impacted on the students'

performance. Students' self-confidence was also examined from a gender perspective.

The sample in the analyses presented were responses from the international databases, including science achievement scores along with student and science teacher background questionnaire responses for Singapore. SAS was utilised to compute various statistics and the corresponding standard errors. We looked into the performance by gender of the students on the TIMSS 2007 science items. We also aimed to study student and school level characteristics using multilevel modelling with student gender as one of the estimates.

Finding and Discussion

The data shows that students from Singapore are the highest performers in Science. Although, girls (scaled score 571) have slightly better scaled scores when compared to boys (scaled score 563), the difference is not significant. However a closer look at the performance within the four content domains shows some differences. Girls in Singapore performed significantly better than boys in Biology and Chemistry. Boys did better than the girls only in Physics but the difference was not significant. Girls from Singapore were better performers than boys in Earth Science although the difference was not significant (see Martin, Mullis, & Foy, 2008). Regarding the cognitive domains, girls in Singapore performed better than the boys in all cognitive domains with significant difference in the reasoning domain. It is interesting to note that among the top performing countries only girls from Singapore did better than the boys in the reasoning domain.

Teachers Gender

There are approximately 2 female science teachers for every male science teacher. Singapore has a larger proportion of younger science teachers when compared to the other top performing countries (table not included due to space constraints). To look at which gender combinations of teachers and students were more effective, we carried out an analysis similar to what was done by Yung, Wong, Cheng and Lau (2005) for TIMSS 2003 data from Hong Kong.

[Take in Table 1 about here]

Singapore's teachers from all the different age groups were equally capable in their abilities to teach as there was no significant difference in the achievement of students who were taught by the different groups. For Science, girls taught by male teachers achieved the lowest test scores in TIMSS 2003 and TIMSS 2007 (Table 1). Furthermore, girls taught by female teachers outperformed boys taught by male teachers (Table 2). However, there was no

evidence that pupils' achievement by gender for science and teacher gender were dependent.

[Take in Table 2 about here]

Performance by Content and Cognitive Domains

In TIMSS 2007 Grade 8, girls outperformed boys in Biology and Chemistry (Table 3). The same pattern was observed internationally with the exception of boys outperforming girls in Physics. We looked through and tabulated all the achievement items where percentage of students of a gender answering correct and significantly higher than the other gender (Table 4). We seemed to have the reverse for Biology, Chemistry and Physics in the number of items correct. It may be noted that each student answered a portion of the entire set of achievement items and thus Science scaled scores should not be directly linked to the number of items correct.

[Take in Tables 3 & 4 about here]

For each cognitive domain, girls performed as well as boys (Table 5). A closer look at the achievement items suggested that there were more items with percentage of boys answering correct significantly higher than percentage of girls in the Knowledge and Applying domains (Table 6).

[Take in Tables 5 & 6 about here]

Index of Students' Self-confidence in Learning Science

This was a difference between boys' self-confidence in learning science and girls at the high index level. There was significantly higher percentage of boys at this level (see Table 7). We also noted that girls at the middle level had significantly higher achievement scores than boys.

[Take in Table 7 about here]

Correlation and Regression

We attempted to measure the relationship between academic achievement status and school resources while we focused on several measures at the individual and school level within Singapore

First, we look at correlations among the variables. Table 8 below shows the correlations for each of these indicators across all the Singapore students participating in TIMSS 2007. In particular, the 6 variables including valuing science, self-confidence, enjoy learning science, parents' highest education level, school climate and homework are indicators associating most strongly ($p < .001$) with science achievement scores. Further, students' gender has a negative association ($p < .05$) with science achievement while school resources indicator is positively associated ($p < .01$) with the achievement score.

[Take in Table 8 about here]

The results show that being female is associated with an increase in science achievement score. The level in which a student values science is positively associated with science score. So do levels of self-confidence and enjoyment of learning. Parents' highest education level is associated with science score. This suggests that the more educated a students' parents are, the higher the science score are likely to be. A positive school climate is associated with higher science score, and so does having greater resources in schools. Finally, a greater amount of homework is associated with higher science score.

Next, we applied linear regression to estimate the effects of the predictor variables on science achievement while controlling for the others. From Table 9, when the 8 variables students' gender, course of study, valuing science, self-confidence, enjoy learning science, parents' highest education level, school resources, school climate and homework were used to estimate our dependent variable, science achievement, all were statistically significant effect with the exception of school resources. In other words, each of the predictors has considerable impact on science achievement. However, in this regression model, we see a positive effect of being male on science achievement while the amount of homework has a negative effect on science score.

[Take in Table 9 about here]

Hierarchical Linear Model (HLM)

Three models were constructed to represent level 1 and level 2 of the TIMSS 2007 data. For the baseline, the regression equation is as follows.

$$\begin{aligned} Y_{ij} &= \beta_{0j} + \tau_{ij} \\ \beta_{0j} &= \gamma_{00} + u_{0j}. \end{aligned}$$

The multilevel model can be represented as follows:

Level 1 Model (student-related variables):

$$\begin{aligned} Y_{ij} &= \beta_{0j} + \beta_{1j}(\text{Gender}) + \beta_{2j}(\text{Valuing}) + \beta_{3j}(\text{Confidence}) \\ &\quad + \beta_{4j}(\text{Enjoy}) + \beta_{5j}(\text{Parent Education}) + r_{ij} \\ \beta_{kj} &= \gamma_{k0} + u_{kj}. \end{aligned}$$

Level 2 Model (school-related factors):

$$\begin{aligned} Y_{ij} &= \beta_{0j} + \beta_{1j}(\text{Gender}) + \beta_{2j}(\text{Valuing}) + \beta_{3j}(\text{Confidence}) \\ &\quad + \beta_{4j}(\text{Enjoy}) + \beta_{5j}(\text{Parent Education}) + r_{ij} \\ \beta_{kj} &= \gamma_{k0} + \gamma_{k1}(\text{School Resources}) + \gamma_{k2}(\text{School Climate}) + \gamma_{k3}(\text{Homework}) + u_{kj}. \end{aligned}$$

In these models,

Y_{ij} : the Science score of student i in school j ,
 β_{0j} : regression intercept of school j ,
 γ_{00} : the overall average Science score for all schools,
 u_{0j} : the random effect of school j ,
 r_{ij} : the random effect of student i in school j .

Further, for $k = 1, 2, 3, 4, 5$,

β_{kj} refer to regression slopes of school j ,
 u_{kj} refer to the random effects,

γ_{k0} to γ_{k3} refer to the level 2 fixed effects.

The results of the two-level HLM models are shown in Table 10. At the baseline, the intra-class correlation (ICC) was small, suggesting about 9% of the total variance in Science scores occurred between schools. At Level 1, when all the 5 predictors (i.e., gender, valuing Science, self-confidence, enjoy learning and parents' education) were included in the model to predict Science achievement, it appeared that more than 36% of the variance in Science achievement was accounted for. In terms of fixed effects, all the variables were statistically significant. At the school level, school climate and homework had a significant relationship with science achievement. On the other hand, school resource was not significant. The full model appeared to account for more than 57% of the total variance in science achievement in Singapore.

[Take in Table 10 about here]

The multilevel model suggested that the indicators (students' gender, valuing science, self-confidence, enjoy learning science, parents' highest education level, school climate and homework) were significant predictors of student achievement in science. Just as the results from the linear regression model, there was a positive effect of being male on science score and the amount of homework has a negative effect on science achievement.

Conclusion and Implications

Although the overall data does not show significant differences between female and male students' scale scores in science in TIMSS 2007, there exists some differences when content and cognitive domains are examined a bit more closely. For example, girls performed significantly better than boys in Biology and chemistry but not in Physics. Also, while girls performed as well as boys in each cognitive domain, there were more items in which boys

answered significantly better than girls in the Knowledge and Applying domains. The HLM suggested some indicators such as gender, valuing science and self-confidence, amongst others, were significant predictors of student achievement in science. The analysis shows that gender is a complex factor in science in Singapore. What appears on the surface to be equitable to the two genders may not be so when examined at another level. It is good to note that girls in Singapore are doing as well as boys in some domains unlike girls in some other countries. On the whole, gender differences in science are not so alarming to bring about any kind of major policy changes.

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Table 1: TIMSS 2003 Grade 4 and TIMSS 2007 Grade 8 Mean Scores for Science by Teacher/Student Gender

Year	F/G	F/B	M/G	M/B	Chi-square	p-value
2003 Grade 4	573 (6.0)	573 (6.7)	521 (10.7)	535 (12.4)	0.0966	0.756
2007 Grade 8	578 (6.0)	567 (6.4)	556 (9.7)	557 (8.4)	0.0623	0.803

() Standard errors appear in parenthesis

F: Female teacher M: Male teacher B: Boy G: Girl

Table 2: Comparison of TIMSS 2003 Grade 4 and TIMSS 2007 Grade 8 Mean Science Scores by Teacher/Student Gender

TIMSS 2003 Grade 4	F/G	F/B	M/G	M/B	TIMSS 2007 Grade 8	F/G	F/B	M/G	M/B
F/G	○	○	▲	▲	F/G	○	○	○	▲
F/B	○	○	▲	▲	F/B	○	○	○	○
M/G	▼	▼	○	○	M/G	○	○	○	○
M/B	▼	▼	○	○	M/B	▼	○	○	○

F: Female teacher M: Male teacher B: Boy G: Girl

An arrow pointing upwards indicates the group in the row has a significantly higher mean score than the corresponding group in the column.

A downward arrow indicates a significantly lower mean score (of the row group relative to the column group).

Table 3: Average Scale Scores for Science Content Domains in TIMSS 2007 Grade 8

Country	Biology		Chemistry		Physics		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	570 ▲ (4.4)	558 (5.1)	567 ▲ (4.2)	554 (5.0)	574 (4.4)	577 (4.6)	543 (4.2)	538 (5.2)
International	471 ▲	460	471 ▲	460	464	468 ▲	466	466

Avg.	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.5)	(0.6)
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() Standard errors appear in parenthesis Source: Exhibit 3.3 in (Martin, 2008)

Table 4: Performance in number of Science achievement items by Content Domains and Gender in TIMSS 2007

Content Domain	Items not released			Released items			Total
	Girls better	No difference	Boys better	Girls better	No difference	Boys better	
Biology	10	34	5	3	28	1	81
Chemistry	2	22	1	4	11	1	41
Physics	3	4	29	3	5	13	57
Earth Science	1	18	3	1	18	1	42
Total	16	78	38	11	62	16	221

Table 5: Average Scale Scores for Science Cognitive Domains in TIMSS 2007 Grade 8

Country	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	570 (4.4)	585 (4.9)	556 (4.8)	552 (5.2)	572 (4.2)	556 (4.7)
International Avg.	468 (0.6) ▲	463 (0.6)	468 (0.6) ▲	464 (0.6)	477 (0.6)	467 (0.7)

() Standard errors appear in parenthesis Source: Exhibit 3.3 in (Martin, 2008)

Table 6: Performance in number of Science achievement items by Cognitive Domains and Gender in TIMSS 2007

Cognitive Domain	Items not released			Released items			Total
	Girls better	No difference	Boys better	Girls better	No difference	Boys better	
Knowledge	6	32	13	5	27	5	88
Applying	4	35	20	3	18	11	91

Reasoning	6	11	5	3	17	0	42
Total	16	78	38	11	62	16	221

Table 7: Index of Grade 8 Students' Self-Confidence in Learning Science (SCS) in TIMSS 2007

Country		High SCS		Medium SCS		Low SCS	
		Girl	Boy	Girl	Boy	Girl	Boy
Singapore	Percentage	34	47	39	38	27	16
		(1.2)	(1.2) ▲	(1.0)	(1.2)	(1.0) ▲	(0.8)
	Achievement	605	598	555	533	553	537
		(5.4)	(5.4)	(5.5) ▲	(6.8)	(6.0)	(8.2)

() Standard errors appear in parenthesis

▲ Mean significantly higher than the opposite gender

Table 8: Correlations

	Science	Gender	Valuing Science	Self confidence	Enjoy learning	Parents' education	School resources	School climate	Homework
Science	1.0000	-0.0222 *	0.2849 ***	0.2398 ***	0.2809 ***	0.3159 ***	0.0260 **	0.3666 ***	0.1547 ***
Gender	-0.0222 *	1.0000	0.0192 *	0.1479 ***	0.0636 ***	-0.0130	0.0362 ***	0.0657 ***	-0.0019
Valuing Science	0.2849 ***	0.0192 *	1.0000	0.3176 ***	0.4532 ***	0.1285 ***	-0.0082	0.0681 ***	0.1259 ***
Self confidence	0.2398 ***	0.1479 ***	0.3176 ***	1.0000	0.5324 ***	0.1339 ***	-0.0049	0.0908 ***	0.0324 **
Enjoy learning	0.2809 ***	0.0636 ***	0.4532 ***	0.5324 ***	1.0000	0.1159 ***	-0.0118	0.1117 ***	0.0934 ***
Parents' education	0.3159 ***	-0.0130 0.1807	0.1285 ***	0.1339 ***	0.1159 ***	1.0000	0.0075	0.1586 ***	0.0478 ***
School resources	0.0260 **	0.0362 ***	-0.0082	-0.0049	-0.0118	0.0075	1.0000	0.0164	0.0490 ***
School climate	0.3666 ***	0.0657 ***	0.0681 ***	0.0908 ***	0.1117 ***	0.1586 ***	0.0164	1.0000	0.0246 **
Homework	0.1547 ***	-0.0019	0.1259 ***	0.0324 **	0.0934 ***	0.0478 ***	0.0490 ***	0.0246 **	1.0000

*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$

Table 9: Regression

Variables	Estimate	Standard error	
Science	217.90	13.05	
Gender	5.60	2.01	*
Valuing Science	7.06	1.38	***
Self confidence	17.62	1.28	***
Enjoy learning	8.31	1.60	***
Parents' education	3.57	0.46	***
School resources	-0.07	5.12	Not significant
School climate	31.80	2.43	***
Homework	-5.41	1.16	***

*** $p < 0.001$ * $p < 0.05$

Table 10: Parameter estimation for full models

Model	Parameter	Estimate	
Baseline	Intra Class Correlations (ICC)	0.0916892649	
	Intercept	559.93634733	***
	σ^2	53310.57812	***
	τ	5381.4267853	***
Level 1	Intercept	565.9875625	***
	Gender	5.61217232	***
	Course of study	72.91097557	***
	Valuing Science	2.356541708	***
	Self confidence	14.16601647	***
	Enjoy learning	4.010552154	***
	Parents' education	2.088032143	***
	σ^2	43116.376321	***
	τ	4487.7641203	***
	R_1^2	0.1912228709	
R_2^2	0.1660642615		
Level 2	Intercept	567.8530355	***
	School resources	1.044883573	Not significant
	School climate	15.55119069	***
	Homework	-2.542977536	***
	Gender	6.082607938	***
	Course of study	72.733537	***
	Valuing Science	2.607034121	***
	Self confidence	13.91437253	***
	Enjoy learning	4.03945629	***

Parents' education	2.170415973	***
σ^2	41994.176679	***
τ	3444.6597256	***
R_1^2	0.2122730955	
R_2^2	0.3598984316	

*** $p < 0.001$