# Dispositions towards Science and Science Achievement in TIMSS 2011: A Comparison of Eighth Graders in Hong Kong, Chinese Taipei, Japan, Korea, and Singapore

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## Abstract

*East Asian education systems have consistently been outperforming their counterparts in mathematics and science on each and every cycle of the Trends in International Mathematics and Science Study (TIMSS) ever since its inception in 1995. This study explored the predictive effects of eighth-graders' dispositions towards science on science achievement in five of the highest-performing education systems: Hong Kong, Chinese Taipei, Japan, Korea, and Singapore, which participated in the TIMSS 2011. The results of the present study indicated that eighth-graders' liking and valuing of learning science, and confidence in learning science were positively associated with their science achievement in these five education systems, except students' liking of science in Japan.*
*Keywords: Dispositions towards science; science achievement; East-Asian education systems; TIMSS*

## 1. Introduction

Factors that might have contributed to the outstanding performance of the East Asian countries are multi-faceted, and such factors have been widely researched recently, including cognitive, affective (i.e., interest, attitude, and motivation), as well as psycho/sociological aspects (see Ong & Gonzalez, 2012; Ong, Gonzalez, & Shanmugam, 2013). The purpose of the present study, however, is to examine the predictive effects of an affective factor, i.e., students' dispositions towards science on science achievement among eighth grade students in Chinese Taipei, Hong Kong, Japan, Korea, and Singapore who participated in the TIMSS 2011 assessment.

## 2. Rationale and Research Questions

These five countries were chosen for the following reasons. Firstly, the educational systems of these countries share some similarities in terms of socio-cultural background. Secondly, the purpose of this study was to identify areas in which the educational systems of these countries can be improved after analysing eighth grade students' dispositions towards science in these respective countries. In light of the scarcity of empirical research especially on the TIMSS 2011, the research question underpinned this study was: How well do eighth-graders' dispositions towards science predict their achievement in science in Hong Kong, Chinese Taipei, Japan, Korea, and Singapore?

## 3. Method

Data for the study were drawn from the TIMSS 2011 database (http://timssandpirls.bc.edu/timss2011/international-database.html). A total of 24,564 eighth-graders from Hong Kong (n = 4,015), Chinese Taipei (n = 5,042), Japan (n = 4,414), Korea (n = 5,166), and Singapore (n = 5,927) participated in the TIMSS 2011 science assessment.

*Science Achievement.* The TIMSS 2011 science achievement scale was based on 302 items spanning across content (i.e., Biology, Chemistry, Physics, Earth Science) and cognitive (i.e., Knowing, Applying, Reasoning) domains in science. TIMSS uses an imputation

methodology, usually referred to as plausible values, to report student performance. The plausible values, an approach developed by Mislevy and Sheehan (1987, 1989) and based on the imputation theory of Rubin (1987), are random elements from the set of scores (i.e., random draws from the marginal posterior of the latent distribution) that could be attributed to each student. For each student, the mean plausible value was used as a measure of science achievement. The IEA's International Database (IDB) Analyzer for TIMSS, a plug-in for SPSS, was used to combine the five plausible values as well as to produce their average values and correct standard errors.

*Students Like Learning Science*. The Students Like Learning Science scale was developed to measure students' interest in and liking of learning science. The TIMSS 2011 Students Like Learning Science scale was based on five items. All items were rated on a 4-point Likert type scale, ranging from '1' (Disagree a lot) to '4' (Agree a lot). The Cronbach's alpha reliability coefficients for the scale were 0.90, 0.87, 0.89, 0.90, and 0.89 in Chinese Taipei, Hong Kong, Japan, Korea, and Singapore, respectively.

*Students Value Science*. The TIMSS 2011 Students Value Science scale addresses students' attitudes about the importance of the subject and usefulness of the subject, sometimes called attainment value and utility value (Wigfield & Eccles, 2000). The TIMSS 2011 Students Value Science scale was based on six items. All items were rated on a 4-point Likert type scale, ranging from '1' (*Disagree a lot*) to '4' (*Agree a lot*). The Cronbach's alpha reliability coefficients for the scale were 0.89, 0.89, 0.85, 0.88, and 0.87 in Chinese Taipei, Hong Kong, Japan, Korea, and Singapore, respectively.

*Students Confident in Science*. The Student Confident in Science scale assesses students' self-confidence or self-concept in their ability to learn science. The TIMSS 2011 Students Confident in Science scale was based on nine items. All items were rated on a 4-point Likert type scale, ranging from '1' (*Disagree a lot*) to '4' (*Agree a lot*). The Cronbach's alpha reliability coefficients for the scale were 0.92, 0.87, 0.88, 0.91, and 0.91 in Chinese Taipei, Hong Kong, Japan, Korea, and Singapore, respectively.

In addition to these measures, student demographic characteristics such as gender (1 = 'female', 0 = 'male'), home language (1 = 'language of test', 0 = 'another language'), and parents' highest level of education (1 = 'Some primary or lower secondary or no school' to 5 = 'University or higher') were included in the study as control variables.

## 4. Results and Discussion

Table 1, 2, and 3 show the percent of students who 'like learning science, value science, confident in science' with their average science achievement in Chinese Taipei, Hong Kong, Japan, Korea, and Singapore, respectively.

Table 1: *Students Like Learning Science*

| Country | Like Learning Science | | Somewhat Like Learning Science | | Do Not Like Learning Science | | Average Scale Score |
|---|---|---|---|---|---|---|---|
| | Percent of Students | Average Achievement | Percent of Students | Average Achievement | Percent of Students | Average Achievement | |
| Chinese Taipei | 17 (0.8) | 618 (3.4) | 43 (0.7) | 571 (2.7) | 40 (1.1) | 534 (2.6) | 9.0 (0.05) |
| Hong Kong | 28 (1.2) | 561 (4.1) | 51 (0.9) | 534 (3.3) | 21 (1.1) | 506 (4.9) | 9.8 (0.06) |
| Japan | 15 (0.8) | 595 (3.7) | 47 (1.1) | 566 (2.2) | 38 (1.5) | 531 (3.1) | 9.0 (0.06) |
| Korea | 11 (0.5) | 623 (3.8) | 43 (0.9) | 576 (2.1) | 46 (1.1) | 531 (2.2) | 8.7 (0.04) |
| Singapore | 38 (0.8) | 617 (5.2) | 46 (0.7) | 584 (4.2) | 16 (0.5) | 542 (5.4) | 10.2 (0.03) |
| International | 35 (0.2) | 515 (0.8) | 44 (0.2) | 472 (0.8) | 21 (0.2) | 450 (1.1) | |

( ) Standard errors appear in parentheses.

In TIMSS 2011, internationally, at the eighth grade, about one-third (35%) of the students, on average, 'Like Learning Science', and about one –fifth (21%) 'Do Not Like Learning Science'. Accompanying the decrease in liking learning science is a widening achievement gap between students who like learning science (515, on average) and those who do not (450) (Martin, Mullis, Foy, & Stanco, 2012).

Table 2: *Students Value Science*

| Country | Value | | Somewhat Value | | Do Not Value | | Average Scale Score |
|---|---|---|---|---|---|---|---|
| | Percent of Students | Average Achievement | Percent of Students | Average Achievement | Percent of Students | Average Achievement | |
| Chinese Taipei | 12 (0.7) | 612 (4.2) | 30 (0.7) | 586 (2.8) | 58 (1.1) | 543 (2.2) | 8.5 (0.05) |
| Hong Kong | 26 (1.0) | 559 (4.1) | 43 (0.8) | 535 (3.8) | 32 (1.1) | 518 (4.0) | 9.5 (0.04) |
| Japan | 10 (0.7) | 595 (4.9) | 34 (1.0) | 574 (2.7) | 56 (1.1) | 540 (2.7) | 8.5 (0.04) |
| Korea | 14 (0.6) | 607 (4.1) | 40 (0.9) | 574 (2.3) | 46 (1.0) | 535 (2.2) | 8.8 (0.03) |
| Singapore | 41 (0.8) | 616 (4.6) | 43 (0.7) | 583 (4.3) | 17 (0.6) | 546 (5.9) | 10.2 (0.03) |
| International | 41 (0.2) | 502 (0.8) | 33 (0.2) | 477 (0.8) | 26 (0.2) | 457 (1.1) | |

( ) Standard errors appear in parentheses.

Internationally, on average, eighth grade students in general or integrated science countries placed a high value on science. Forty-one percent were in the 'Value' category and another 33 percent were in the 'Somewhat Value' category, on average. However, about one-fourth (26%) were in the 'Do Not Value' category. Across the eighth grade, students who said they valued science typically had higher achievement than students who only valued it somewhat, and those students, in turn, had higher achievement than students who did not value science (Martin, et al., 2012).

Table 3: *Students Confident in Science*

| Country | Confident | | Somewhat Confident | | Not Confident | | Average Scale Score |
|---|---|---|---|---|---|---|---|
| | Percent of Students | Average Achievement | Percent of Students | Average Achievement | Percent of Students | Average Achievement | |
| Chinese Taipei | 6 (0.4) | 648 (4.9) | 27 (0.9) | 599 (3.1) | 67 (1.0) | 543 (2.3) | 8.3 (005) |
| Hong Kong | 8 (0.6) | 579 (4.9) | 47 (1.1) | 544 (4.1) | 45 (1.3) | 520 (3.4) | 9.2 (0.04) |
| Japan | 3 (0.3) | 631 (7.7) | 28 (0.9) | 591 (2.6) | 69 (1.1) | 540 (2.6) | 8.4 (0.04) |
| Korea | 4 (0.3) | 652 (4.6) | 33 (0.8) | 603 (2.1) | 63 (0.9) | 532 (1.9) | 8.7 (0.03) |
| Singapore | 14 (0.5) | 630 (5.9) | 48 (0.7) | 600 (4.8) | 37 (0.8) | 562 (4.2) | 9.6 (0.03) |
| International | 20 (0.2) | 536 (1.0) | 49 (0.2) | 482 (0.8) | 31 (0.2) | 450 (0.9) | |

( ) Standard errors appear in parentheses.

Internationally, on average, only 20 percent of the eighth grade students in general or integrated science countries expressed confidence in their science ability, with 49 percent 'Somewhat Confident' and 31 percent 'Not Confident' (Martin, et al., 2012).

To address the purpose of the study, separate simultaneous multiple regression analyses were conducted for each education system to determine whether students' dispositions towards science were predictive of science achievement (see Table 4). Eighth-graders in Chinese Taipei, Hong Kong, Korea, and Singapore who liked learning science very much scored significantly higher on the TIMSS science assessment than their peers who did not like learning science. Similarly, eighth-graders in Chinese Taipei, Hong Kong, Japan, Korea, and Singapore who greatly valued learning science and were more confident in learning science also scored significantly higher on the TIMSS science assessment than their peers who did not value learning science and were less confident in learning science.

In terms of student demographic characteristics, female students significantly outperformed their male counterparts in Chinese Taipei and Korea. Eighth graders in Chinese Taipei, Japan, and Singapore who speak the language of the test at home scored significantly higher in science achievement as compared to those who speak other languages. Students whose parents obtained higher level of education scored significantly higher in science achievement than their peers whose parents obtained lower level of education.

Table 4: *Eighth-Graders' Dispositions towards Science Predicting their Science Achievement*

|  | Chinese Taipei | | Hong Kong | | Japan | | Korea | | Singapore | |
|---|---|---|---|---|---|---|---|---|---|---|
|  | B | SE | B | SE | B | SE | B | SE | B | SE |
| Gender | 9.11* | 2.46 | 3.89 | 3.73 | 4.09 | 2.92 | 5.36* | 2.74 | 0.17 | 3.14 |
| Home language | 14.74* | 2.48 | -5.42 | 3.01 | 21.00* | 5.31 | -5.89 | 2.62 | 12.59* | 1.92 |
| Parental education | 20.42* | 1.48 | 10.57* | 1.88 | 16.56* | 1.78 | 15.71* | 1.37 | 21.48* | 1.85 |
| Students like science | 4.68* | 1.14 | 6.13* | 1.33 | 0.65 | 1.43 | 4.24* | 1.09 | 7.74* | 1.21 |
| Students value science | 6.44* | 1.00 | 3.00* | 1.04 | 8.13* | 1.21 | 5.97* | 1.00 | 5.50* | 1.11 |
| Students confident in science | 7.72* | 0.91 | 3.85* | 1.13 | 13.90* | 1.23 | 14.48* | 1.05 | 3.39* | 1.07 |
| Adjusted $R^2$ | 0.29 | | 0.13 | | 0.25 | | 0.30 | | 0.22 | |

TIMSS routinely presents very powerful evidence showing that within countries, students with more positive attitudes toward science have substantially higher achievement, and the results from TIMSS 2011 are consistent with previous assessments (Martin, et al., 2012). There is extensive research showing that students with more positive attitudes toward mathematics and science have higher average achievement in mathematics and science (Martin, et al., 2012; Mullis, Martin, Foy, & Arora, 2012). For example, a recent meta-analysis of student attitudes toward school found that attitudes toward mathematics or science were related to mathematics and science achievement across 288 studies (Hattie, 2009).

## Conclusion

This study found that eighth-graders in Chinese Taipei, Hong Kong, Korea, and Singapore who liked learning science very much scored significantly higher on the TIMSS science assessment than did their peers who did not like learning science Similarly, eighth-graders who greatly valued learning science and were more confident in learning science also scored significantly higher on the TIMSS science assessment than did their peers who did not value learning science, and were less confident in learning science in Chinese Taipei, Hong Kong, Japan, Korea, and Singapore.

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