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# Three G7 And Three Little Asian Dragons In TIMSS Mathematics At The Fourth Grade

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## ABSTRACT

Three G7 countries (USA, UK, and Canada) and three Asian Little Dragons (Hong Kong, Korea, and Singapore were compared on demographic variables, TIMSS achievement, teachers' and students' behaviours relevant to mathematics learning. The Asian countries spent more on education and outperformed the European countries in the TIMSS test as a whole and the various sub-tests which are highly correlated among themselves, except in Geometry where no difference is found. There is a very high correlation between TIMSS achievement and item-curriculum match analysis. Asian teachers spent more time on out-of-class coaching, taught larger classes, but did *less* practice of computation in their lessons. Less Asian students possessed the three specified educational aids but more spent time doing homework. They did not think having time to have fun important and believed their mothers and friends held the same view. These variables correlate significantly with TIMSS performance.

## Introduction

IEA's Third International Mathematics and Science Studies (TIMSS) is, by definition, a sequel to the two earlier studies. In conducting this study, meticulous care was taken by the national experts to ensure proper sampling and instrumentation for quality assurance so as to ensure valid comparison across countries. The study could serve as an international league table, a bench-marking exercise in an international context, and a database for an investigation into the mechanisms of mathematics achievement with the broadest view available on planet earth.

The present paper takes the last perspective as a frame of reference with the intent of uncovering some of the many hidden facts that could be teased out from the mass of information contained in the relevant report (Mullis, Martin, Beaton, Gonzalez, Kelly, and Smith, 1997). Specifically, this paper contrasts the mathematics performances of Grade Four students in six countries and relates this to plausible contributing factors.

The six selected countries include USA, UK, and Canada of the G7 (or G8, now that Russia has joined the club recently) and Hong Kong, Korea, and Singapore of the four Asian Little Dragons. Japan is excluded here as she is the only Asian country among the G7 (G8) and her 'membership' in the context of this comparison is ambiguous. The three European countries will hereafter be referred to as the Greats, an the latter Dragons. It is believed that the two groups of selected countries provide sufficient contrast as the Greats are long-established developed industrial countries while the latter group represent the new industrial nations.

Differences in demographic variables, teacher variables, and student variables will be studied first, followed by a correlational analysis to investigate possible correlations between achievement and contributing factors. All data were extracted from Mullis et al. (1997).

## Do The Dragons And Greats Differ In Their Demographic Characteristics?

As can be seen from Table 1, on average, the two groups of nations do not differ in GNP per capita, percent of correct age children in secondary school, and expenditure on education as percent of GNP. However, the Dragons spend more dollars on education per student than do the Greats, in the proportion of 3.8:1.

Table 1. Comparisons of Demographic Characteristics

| Variables | Dragons | Greats | t |
|---|---|---|---|
| GNP per capita | 21280.0 (4008.6) | 11248.3 (10917.2) | 1.494 |
| % in secondary school | 92.5 (6.36) | 91.7 (7.04) | 0.133 |
| Expenditure as % GNP | 4.1 (0.5) | 2.7 (7.1) | 1.798 |
| Expenditure on education | 890.0 (210.8) | 231.7 (181.8) | 4.097* |

Notes: (1) Gross national product per capita in US. (2) % in secondary school of school-age children. (3) Expenditure as % GNP for levels 1 & 2. (4) Expenditure on education in international dollars per capita.
* For df 4, t=2.132, p<0.05.

## In what way do the Dragons and the Greats differ in mathematics achievement?

As shown in Table 2, there is a significant difference in the mean achievement between the Dragons and the Greats, with a difference of 77.7 points in favour of the Dragons. This difference represents an effect size of 4.05, indicating that the Dragons lie far out of the range of the Greats.

Table 2. Comparisons of TIMSS Achievement Variables

| Variables | Dragons | Greats | t |
|---|---|---|---|
| Mean | 607.7 ( 19.2) | 530.0 (16.1) | 5.367* |
| Overall maths | 75.0 (1.7) | 60.0 (3.0) | 7.500* |
| Whole number | 83.3 (4.5) | 65.7 (6.8) | 3.748* |
| Fraction | 68.3 (4.9) | 48.0 (3.0) | 6.100* |
| Measurement | 69.3 (2.5) | 53.0 (1.0) | 10.447* |
| Data presentation | 79.0 (2.6) | 68.3 (4.5) | 3.534* |
| Geometry | 72.7 (1.2) | 72.3 (1.5) | 0.302 |
| Pattern | 77.3 (5.1) | 61.0 (5.6) | 3.730* |
| Test-curriculum match % | 75.0 (1.7) | 60.0 (3.0) | 7.500* |

Notes: (1) The test has 113 items and the score are scaled to have mean 500 and SD 100. (2) Fraction: Fraction & proportionality. (3) Measurement: Measurement, estimation, & number sense. (4) Data presentation: Data presentation, analysis, & probability. (5) Pattern: Pattern, relations, & functions.
* For df 4, t=2.132, p<0.05.

With the glaring difference above, differences in the more specific areas of mathematics can be expected. This is in fact shown in Table 2, too. Out of the seven sub-fields, the Dragons out performed the Greats in six, namely, overall mathematics, whole number, fraction, measurement, data presentation, and pattern. The only exception is geometry in which the Dragons and the Greats did equally well.

It is also interesting to note that there is a significant difference in Test-Curriculum match Analysis. This is the percent of the 113 items of the TIMSS test checked by the respective country experts as consistent with their national mathematics curriculum. The match is 75% for the Dragons and 60 for the Greats. That the Dragons did better could at least be partly attributed to this difference in test-curriculum match. The difference also means that mathematics curricula of the Greats could well be covering more broadly than those of the Dragons. For instance, in response to the TIMSS results, US Secretary of Education Richard W. Riley said, "Currently, US standards are unfocused and aimed at the lowest common denominators. In other words, *they are a mile wide and an inch deep*" (emphasis added).

These findings would lead to the expectation of high correlations among the various achievement measures. As shown in Table 3, while Geometry stands alone with a non-significant correlation with mean achievement, all other measures, including test-curriculum match, have high correlations with mean achievement and among them as well.

Table 3. Correlations of TIMSS Achievement Variables

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 1.00 | | | | | | | | |
| Overall math | .99* | 1.00 | | | | | | | |
| Whole no. | .95* | .95* | 1.00 | | | | | | |
| Fraction | .98* | .97* | .89* | 1.00 | | | | | |
| Measure-ment | .92* | .95* | .92* | .90* | 1.00 | | | | |
| Data prestn. | .98* | .97* | .97* | .93* | .87* | 1.00 | | | |
| Geometry | -.19 | -.11 | -.31 | -.05 | .01 | -.34 | 1.00 | | |
| Pattern | .94* | .95* | .99* | .97* | .92* | .96* | -.28 | 1.00 | |
| TC match | .99* | 1.00* | .96* | .97* | .96* | .97* | -.11 | .96* | 1.00 |

Note: For fuller information of the variables, see Table 2
* For df 4, r=0.729, p<0.05.

## Do Teachers Of The Dragons And Those Of The Greats Behave Differently In Their Mathematics Teaching?

TIMSS collected information of teacher behaviours with the implicit implications that what a mathematics teacher does will have an influence on student performance. Several significant differences are of interest here (Table 4). Firstly, Dragons teachers spent 80% more time coaching students outside class time than did Greats teachers. Secondly, Dragons teachers had much larger classes to handle. More specifically, classes were about 60% larger for Dragons. Thirdly, practice of computational skills was popular for the Greats than for the Dragons. This is an unexpected finding in view of the more 'progressive' educational philosophy commonly assumed to be prevalent in the Greats countries. Other than these, teachers of the six countries did not differ significantly in the time/week spent marking students' assignments, using whole-class teaching and group/pair work, practice of reasoning skills, and the amount of homework they set. Incidentally, 27.3% more Dragons teachers than Greats teachers reported the use of whole-class teaching. The difference is however non-significant. This could well be due to the large standard deviations indicating that the use of whole-class teaching varies greatly among countries.

Table 4. Comparisons of TIMSS Teacher Variables

| Variables | Dragons | Greats | t |
|---|---|---|---|
| Male Maths teachers | 29.3 (9.9) | 19.7 (5.5) | 1.482 |
| Hours/week marking | 5.9 (2.0) | 5.0 (0.4) | 0.784 |
| Hours/week coaching | 1.8 (0.5) | 1.0 (0.1) | 3.302* |
| Average class size | 39.3 (3.5) | 25.3 (2.3) | 5.769* |
| Whole-class teaching | 61.3 (20.0) | 34.0 (21.7) | 1.611 |
| Group/pair work | 19.3 (14.4) | 21.7 (2.10) | 0.278 |
| Practice of computation | 40.0 (4.6) | 52.5 (3.50) | 3.213* |
| Practice of reasoning | 41.3 (19.4) | 51.5 (3.5) | 0.888 |
| Homework | 48.0 (13.1) | 47.5 (26.2) | 0.025 |

Notes: (1) Figures in table are percentages unless otherwise specified. (2) Homework assigned per week 3 or more times, up to 30 minutes
* For df 4, t=2.132, p<0.05.

## Do Students Of The Dragons And Those Of The Greats Behave And Think Differently Where Their Mathematics Learning Is Concerned?

TIMSS also was interested in student variables that might have an influence on achievement (Table 5). The first such measure is having all three educational aids which include dictionary, desk for study, and computer. On this measure, the difference between the Dragons and the Greats is not unexpected. The second measure of interest is the percent of students using the test language at home. Although there is no significant difference between the Dragons and the Greats, it is of note that, while such percentage is high in Japan and Korea, no less than 80% of the students did not use the test language (in this case, English) as their home language, in spite of their high achievement in the TIMSS test. The large variation among the Dragons in the use of test language at home is indicated by the sizeable standard deviation.

Table 5. Comparisons of TIMSS Student Variables

| Variables | Dragons | Greats | t |
|---|---|---|---|
| Have educational aids | 31.0 (9.0) | 62.7 (13.9) | 2.270* |
| Test language at home | 54.5 (48.8) | 88.0 (4.3) | 0.968 |
| Do well: Self | 88.7 (14.5) | 97.3 (0.9) | 1.037 |
| Doing well: Mother | 87.0 (14.7) | 98.0 (0.0) | 1.293 |
| Doing well: Friends | 69.0 (21.8) | 77.0 (4.6) | 0.622 |
| Have fun: Self | 62.7 (9.0) | 94.3 (1.5) | 6.033* |
| Have fun: Mother | 47.7 (17.6) | 90.0 (2.0) | 4.149* |
| Have fun: Friends | 69.3 (7.5) | 91.7 (1.5) | 5.729* |
| Homework | 46.0 (5.7) | 29.0 (4.2) | 3.400* |
| Usually do well | 24.0 (9.9) | 39.3 (5.7) | 1.983 |
| Like maths a lot | 40.3 (10.2) | 50.7 (1.2) | 1.741 |
| Strong positive attitude | 35.7 (11.6) | 46.7 (3.1) | 1.595 |

Notes: (1) Figures in table are percentages. (2) Educational aids: dictionary, study desk, & computer. (4) Homework for 1 hour or more on school day
* For df 4, t=2.132, p<0.05..

Another interesting finding of student variables is that students in all six countries acknowledged the importance of doing well in mathematics. Not only this, they also perceived their mothers and friends as holding the same view. Even more interestingly, a much lower percentage of Dragons students believed that having time to have fun is important, to themselves, to their mothers, and to their friends. This stands out in stark contrast to the views of their Greats counterparts as indicated by the significant differences. However, Dragons and Greats students did not differ in their self-confidence where mathematics is concerned, neither did they differ in their liking for and attitude toward mathematics.

## Which Teacher And Student Variables Could Have Contributed To Mathematics Achievement?

The TIMSS may provide an international league table like those for other sphere of life such as economic well-being, business environment, airport facilities, etc. But, its most educational and hence valuable contribution is the insight into what make good mathematics achievement in a broader context beyond national boundaries. For an understanding of this, it is useful to look into the correlates of TIMSS achievement which are shown in Table 6.

Table 6. Correlations of TIMSS Achievement with Teacher Variables

| Teacher variables | Correlations |
|---|---|
| Male Maths teachers | .337 |
| Hours/week marking | .373 |
| Hours/week coaching | .848* |
| Average class size | .889* |
| Whole-class teaching | .833* |
| Group/pair work | .091 |
| Practice of computation | -.717 |
| Practice of reasoning | -.052 |
| Homework | -.079 |

Note: For fuller information of the variables, see previous tables..
* For df 4, r=0.729, p<0.05, one-tailed test.

Of the nine correlation coefficients for teacher variables, only three turn out to be significant. These include time for out-of-class coaching, class size, and practice of whole-class teaching. Practice of computational skills has a sizeable negative correlation with achievement, although it missed the level of significance by a small margin. It is also interesting to note that practice of reasoning skills has a negligible correlation with achievement; this in a way is unexpected, since mathematics is supposedly a subject requiring much thinking (reasoning).

As for student variables, Table 7 shows five of the 12 variables to have significant correlations with achievement, and all in the negative! While it is readily appreciated why the three 'fun" measure have negative correlations, the *negative* correlations of having educational aids and homework with achievement are puzzling. After all, should having educational aids and doing homework help in the learning of mathematics? Moreover, the correlation of practice of computational skills is sizeable (although it misses the significance level by a small margin) but in the negative, suggesting that emphasises on this is detrimental to mathematics learning, quite contrary to common-sense that practice makes perfect.

Table 7. Correlations of TIMSS Achievement with Student Variables

| Student variables | Correlations |
|---|---|
| Have educational aids | -.762* |
| Test language at home | .680 |
| Doing well: Self | -.444 |
| Doing well: Mother | -.535 |
| Doing well: Friends | -.091 |
| Have fun: Self | -.876* |
| Have fun: Mother | -.784* |
| Have fun: Friends | -.861* |
| Homework | .831* |
| Usually do well | .499 |
| Like maths a lot | -.496 |
| Strong positive attitude | -.471 |

Note: For fuller information of the variables, see previous tables..
* For df 4, r=0.729, p<0.05, one-tailed test.

## What Can We Learn From All These?

This study compares three G7 countries (USA, UK, and Canada) and three Asian Little Dragons countries (Hong Kong, Korea, and Singapore) on TIMSS performance and some relevant variables.

Firstly, the three Asian countries spent nearly four times more on education per student than do the European countries. This could mean one of two things or both. Firstly, the Dragons traditionally value education and also see education as the route to a brighter economic future, more than do the Greats. Secondly, education in the Asian countries is still in the process of developing, compared with the more stabilised state of affairs among the European countries, and hence more financial resource is put into it.

Secondly, the Asian countries outperformed the European countries (with an effect size of 4!) on the TIMSS test as a whole and hence on all components of the tests, too, with the exception of Geometry for which there is no difference. Not unexpectedly, the various components of TIMSS test correlate highly among themselves while the Geometry component stands alone. This suggests that there is a general mathematical ability which cuts across sub-fields of primary school mathematics involving the kind of abilities tapped by the constituents of the TIMSS test. However, Geometry, which is more loaded by visual perception in additional to the demand on conceptual understanding, requires a different kind of ability. This has obvious implications for curriculum design, methodology, and assessment where primary school mathematics is concerned.

Thirdly, There are perfect or near perfect correlations between TIMSS performance and item-curriculum match and there is also a closer item-curriculum match for the Asian countries. This prompted a further investigation by studying the correlations using the two tables in Harris, Keys, and Fernandes (1998). Here, Japan and Singapore are the only two Asian countries, the other nine are European countries. A very high Spearman's rho=0.875 ($p<0.05$) was found (Table 8). Such a high level of consistency between TIMSS performance and item-curriculum match indicates that countries with higher match did better than those for which the match was low. Moreover, the match indices are rather low, varying from a low 36% (Norway) to only as high as 63% (Japan). It is understandable that the TIMSS test has to be built on the common core of mathematics of the country syllabuses. This, however, also poses a constrain on the cross-nation comparisons which can be validly made only with reference to the topics covered by the test.

Table 8. Mathematics Test-curriculum Matching Analysis and Median Mathematics Achievement in Nine Countries (Fourth Grade)

| Country | T-C Match (113 item) | | Maths Achievement | |
|---|---|---|---|---|
| | Percent | Rank | Median | Rank |
| Japan | 63 | 1 | 544 | 2 |
| Singapore | 62 | 2 | 569 | 1 |
| Netherlands | 52 | 3 | 512 | 3 |
| United States | 49 | 4.5 | 503 | 5 |
| Hungary | 49 | 4.5 | 491 | 7 |
| Canada | 47 | 6 | 504 | 4 |
| Scotland | 45 | 7.5 | 502 | 6 |
| England | 45 | 7.5 | 476 | 8 |
| Norway | 36 | 9 | 473 | 9 |

Source: Table2.2.3 and 2.4.1. from Harris, S., Keys, W., and Fernandes, C. (1998).

This suggests that the TIMSS test as a whole tested only some parts of the mathematics the students in different countries learned and some other parts they had learned were not tested. This raises the question of the across-country validity of the TIMSS test.

Fourthly, Asian teachers spent more time on out-of-class coaching, taught larger classes, but did ***less*** practice of computation in their lessons. These three variables correlate significantly with TIMSS performance. Since time is a crucial factor of achievement as research has established, it is not surprising that there is a high correlation between out-of-class coaching and TIMSS performance. The positive correlation between TIMSS achievement and larger class size seems to be contrary to common-sense, as advocates would argue that small class size will allow for more individual attention and hence performance of the students as a whole. And, the ***negative*** correlation between practice of computational skills and TIMSS performance is also surprising, especially taking into consideration the finding that practice of reasoning skills has a negligible correlation with performance. The last two points do beg questions as to why larger class size and *less* practice of computational skills have contributed to mathematics achievement. Obviously, further study is indicated.

Finally, less Asian students possessed the three specified educational aids (dictionary, computer, and study desk) but more spent time doing homework. They did not think having time to have fun important, and they believed their mothers and friends also held the same view. These variables correlate significantly with TIMSS performance. These finding seem to indicate that Mathematics as a thinking subject calls for time and motivation, and material support may or may not help. That students in the Asian countries think having time for having fun is not important, not only to themselves but also to their mothers and friends, is a starkly different orientation compared with the views held by students if the European countries. This, in a way, reflects the philosophy of life of the two worlds. However, when the Asian countries become increasingly affluent (that is, when they get over the recent economical turmoil), will this still be the case is something to watch out for.

## Reference

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