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# Schools in Singapore with High Performance in Mathematics at the Eighth Grade Level

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**Abstract**: The Third International Mathematics and Science Study (TIMSS) is the largest and most comprehensive comparative study of education ever undertaken. It was conducted in 1995 with the participation of more than 40 countries. The wealth of data made available by TIMSS has led to many secondary studies of educational systems around the world. One such study was "Effective Schools in Science and Mathematics". This paper is based on the data and findings of that study where the characteristics of schools and, in turn, classrooms in Singapore with high performance in mathematics at the eighth grade level (secondary two) are examined. Among the 14 predictors of grade 8 mathematics achievement, only six were found to be significant for Singapore. These were associated with homework, classroom environment, students' conduct and future aspirations, and the teacher.

## Background: TIMSS Study

The Third International Mathematics and Science Study (TIMSS) is the largest, most comprehensive, and most rigorous international study of schools and student achievement ever conducted (Kelly, Mullis, & Martin, 2000). In 1995 more than 40 countries participated in an assessment of mathematics and science achievement at the fourth, eight and twelfth grades. In 1999, the Third International Mathematics and Science Study - TIMSS-R (Mullis et al., 2000) was replicated at the eighth grade.

Singapore participated in TIMSS at Populations 1 and 2 levels (Research & Testing Division, MOE; 1996). Population 1 comprised grade three (Primary 3) and grade four (Primary 4) students and Population 2 comprised grade seven (Secondary 1) and grade eight (Secondary 2) students. A total of 14 484 primary (7216 Primary 3 and 7268 Primary 4) and 8285 secondary (4644 Secondary 1 and 3641 Secondary 2) students participated in TIMSS.

### The Tests

For Population 2, the TIMSS tests (Research & Testing Division, MOE, 1996) contained 151 mathematics and 135 science items representing a range of mathematics and science topics and skills. Both multiple-choice and open-ended questions were administered. The tests were assembled in eight booklets. The number of mathematics questions ranged from 33 to 42 in each booklet and the

number of science questions from 29 to 38. Students were randomly assigned a booklet. Testing time was one and a half hours.

**The Questionnaires**

Questionnaires (Beaton, Mullis, Martin, Gonzalez, Kelly, & Smith, 1996) were used to collect data from all the participants of TIMSS: students, teachers and school leaders. Briefs of the three questionnaires follow.

Student Questionnaire: The student questionnaire elicited information from the students about resources for learning in their homes, their attitudes towards mathematics and science, their learning experiences in school, frequency of occurrence of a range of classroom instructional activities, and their perception of their school's social climate.

Teacher Questionnaire: The teacher questionnaire gathered information from the mathematics teachers of students participating in TIMSS such as their academic and professional qualifications, their perceptions about mathematics and the learning of mathematics, how they spend their school-related time, how their mathematics classes were organized, nature of activities they used in their instruction, the amount of homework assigned, the assessment approaches adopted, and the use of calculators and computers in their classes.

The School Questionnaire:

The school questionnaire gathered information from the school administrators concerning the location of the school, the enrolment of the school and average class size in the school, student violations (tardiness, absenteeism, skipping class & violation of dress code) in their school, and serious problem behaviour (disruptive, cheating, profanity, vandalism & intimidation) among their students in the school.

## Background: Effective Schools in Science and Mathematics Study

In 2000, a secondary analysis of the TIMSS data was carried out by researchers at the TIMSS International Study Centre in Boston College to ascertain the characteristics of effective schools in science and mathematics. This study, Effective Schools in Science and Mathematics (ESSM) (Martin, Mullis, Gregory, Hoyle, & Shen, 2000) used the data made available by TIMSS. As a starting point to identify characteristics of effective schools, the first part of the study divided schools in each country into high-performing and low-performing groups based on average student achievement in eighth grade mathematics. Variables that discriminated between the two groups were noted. Variables that were characteristic of high-performing schools only were retained for further analysis in the second part of the study.

In the second part of the study a home background index was based upon students' reports on the following: number of books in the home, availability of study desk, presence of a computer in the home, education of each parent, number of natural parents in the home, number of persons in the family home, and possessions in the home.

The home background index was used to make a statistical adjustment to each school's average achievement in mathematics to control for differences in student home background. School level factors were then examined as predictors of adjusted school achievement.

To guide the analysis, and to keep the primary focus on classroom instruction and other school factors, the following questions were posed for mathematics:

1) Once average achievement in the school has been adjusted for the effects of students' home background, what classroom practices are associated with mathematics achievement?
2) Do teacher characteristics relate to the adjusted school mathematics achievement when examined alongside classroom practices?
3) What is the relationship of school social climate factors to the adjusted mathematics achievement when classroom practices and teacher experience are also considered?
4) Does school location and size relate to adjusted school achievement when considered in conjunction with classroom activities, teacher characteristics and school social climate?
5) What is the relationship of factors representing student attitude or motivation (mother's pressure, self pressure and students' aspirations) to adjusted school achievement when the other four categories of school-related factors are considered at the same time?
6) Is the average home background of the students in a school related to adjusted school achievement when considered in conjunction with all five categories of variables above?
7) Is adjusted school achievement more strongly related to the combination of average home background and the five categories of variables than average home background alone?

Six hierarchical linear models for each country for mathematics achievement were then constructed. The first model examined the relationship of classroom characteristics to school achievement after considering the home background of the students. Each successive model added another set of explanatory factors to the previous model. Together, these models provided an analysis of the effects of the

various categories of school and classroom variables on school achievement while adjusting for student home background. Details of each model follow:

- Home background – this category includes indicators of both academic emphasis and socioeconomic status. The five variables in this category are number of books in the home, presence of study aids (dictionary, study desk, computer), possessions at home, level of educational attainment of parents, and number of hours spent doing jobs at home every day.

- Home–school interface – this category represents area of interaction between the home and school. The four variables in this category are maternal and student pressure for academic success, student aspirations for university education, and homework frequency.

- School location and size – this category includes factors that operate at the school level. The three variables in this category are school location, size of school, and size of class.

- School social climate – this category is concerned with the psychological context in which school behaviour is embedded. The two variables in this category are serious student misbehaviour – classroom disturbance, cheating, profanity, vandalism, theft, intimidation or verbal abuse of other students and physical injury to other students, and administrative violations – arriving late at school, absenteeism, skipping class and violating dress code.

- Student attitude towards mathematics – an index of student attitude towards mathematics was constructed by averaging student responses to five questions. The questions are: I like mathematics, I enjoy mathematics, mathematics is boring, mathematics is important to everyone's life, and I would like a job that involves using mathematics.

- Instructional activities in mathematics class – the one instructional activity in mathematics that most strongly related to student achievement was the frequency with which mathematics teachers checked homework in class. Therefore the only variable in this category is teacher frequently checks mathematics homework in class.

From this analysis, having adjusted for differences in student home background, fourteen school-level variables were found to be predictors of mathematics achievement. They are

- time spent on homework, in general,
- time spent on homework in mathematics,
- checking mathematics homework in class,
- students' attitude towards mathematics,
- an orderly classroom environment,
- mathematics class size,
- teaching experience of mathematics teacher,
- student administrative violations,
- serious student misbehaviour,
- urban location of school,
- class size,
- future aspirations of students,
- self pressure, and
- mother's pressure.

**Schools with high performance in mathematics from Singapore**

Singapore had the highest average achievement score in mathematics at the eighth grade (Research & Testing Division, MOE, 1996). The difference between the averages of highest and lowest third of schools in Singapore was 128. The largest difference between highest and lowest achieving third of schools in the study was 152. Singapore ranked eighth out of 34. Table 1 shows the achievement average differences between the high-achieving and low-achieving schools in Singapore.

Table 1
*Average mathematics achievement of schools in Singapore*

| Average mathematics achievement of all schools | Average mathematics achievement of lowest third of schools | Average mathematics achievement highest third of schools | Difference between highest and lowest third of schools |
|---|---|---|---|
| 643 | 570 | 698 | 128 |

In the Singapore portion of the ESSM study only six distinguishing characteristics between high- and low- achieving schools were found (significant at 0.1 level). The six, with details provided in Table 2, are

- time spent on homework, in general,
- time spent on homework in mathematics,
- classroom environment,
- teaching experience of mathematics teacher,
- serious student misbehaviour, and
- future aspirations of students.

Table 2
*Data for Singapore schools on characteristics of high– and low–achieving schools in the study*

| Factor | Percent of students | | |
|---|---|---|---|
| | Lowest – achieving third of schools | Highest – achieving third of schools | Is difference statistically significant? |
| ***Home background*** | | | |
| (i) at least 100 books in the home | 15 | 36 | Yes |
| (ii) a study desk, dictionary & computer in the home | 33 | 58 | Yes |
| (iii) a microwave oven, car, air conditioner, piano/organ or violin and domestic help in the home | 29 | 55 | Yes |
| (iv) at least one parent finished university | 2 | 14 | Yes |
| (v) work one or more hours at home (doing household chores) | 62 | 33 | Yes |
| ***Home – school interface*** | | | |
| (i) mother thinks it is important to do well in science, mathematics and language | 98 | 99 | Yes |
| (ii) student thinks it is important to do well in science, mathematics & language | 96 | 99 | Yes |
| (iii) planning to attend university | 23 | 64 | Yes |
| (iv) daily doing of homework in science, mathematics and other subjects | 87 | 95 | Yes |
| ***School location and size*** | | | |
| (i) schools located in urban areas | 100 | 100 | No |
| (ii) enrolment greater than the country mean; country mean = 1226 | 39 | 84 | Yes |
| (iii) average class size greater than the country mean; country mean = 36 | 66 | 61 | No |

| | | | |
|---|---|---|---|
| ***School social climate*** | | | |
| (i) often dealing with serious student misbehaviour | 52 | 20 | Yes |
| (ii) often dealing with student administrative violations | 90 | 55 | Yes |
| ***Student attitude towards mathematics*** | | | |
| (i) having a positive attitude towards maths | 77 | 87 | No |
| ***Instructional activities in math class*** | | | |
| (i) teacher frequently checks homework during lessons | 91 | 94 | No |

## Discussion

There was a significant difference in the average mathematics achievement between the high-achieving third and low-achieving third of schools in Singapore at the eighth grade (secondary two). Partly, this may be due to the fact that students are streamed in secondary schools whereas participants in TIMSS were drawn from all streams and all schools. The other contributing factor is the "academic status" of secondary schools in Singapore. Some are independent and others 'neighbourhood'. The intake of independent schools is the top 10 % of the student cohort based on the Primary School Leaving Examination (PSLE) each year. Neighbourhood schools vary in their intakes, the more popular a school is – the more selective it can be in terms of the academic ability of students.

From Table 2 it is apparent that more students from high achieving schools when compared to students from low achieving schools had at least 100 books, a study desk, dictionary, computer, microwave oven, car, air conditioner, piano/organ or violin, and domestic help in their homes. For these students the chance that at least one parent had university education was also higher but compared to their peers from low achieving schools significantly fewer were doing one or more hours of household chores per day at home. Generally, the home background factor highlights that students from high-achieving schools appeared to have more resources in the home and more time at their disposal for academic pursuits.

The home–school interface factor shows that students and their mothers from both high- and low-achieving schools placed emphasis on the study of science, mathematics and language. Teachers of these students too, placed equal emphasis on their learning of science, mathematics and language as this is shown by the

amount of homework students were set to do each day. As well, about nine-tenths of the students from both low- and high-achieving schools reported doing their homework every day. However, significantly, less than a quarter of the students from low-achieving schools compared to more than sixth-tenths of the students from high-achieving schools planned to attend university.

All the schools were located in urban areas. More than four-fifths of the high-achieving schools but only two-fifths of low-achieving schools had enrolments larger than the country mean. The average class size was larger than the country mean for nearly six-tenths of both the low- and high-achieving schools. The school location and size factor shows that by virtue of Singapore's size all the schools were located in similar settings. However more high-achieving schools were larger in size compared to low-achieving schools but the average class size was larger than 36 (national mean) for nearly the same number of classes that participated in TIMSS from both types of school.

Significantly more students from low-achieving schools were reported to pose serious student misbehaviour and also student-administrative violations. The school social-climate factor shows that the social climate of low-achieving schools when compared to that of high-achieving schools appeared to be less conducive for study. Also, in such schools definitely more resources would be channeled towards addressing the issues of school discipline.

More than three quarters of the students from both low- and high-achieving schools had a positive attitude towards mathematics. Teachers in both low- and high-achieving schools reported frequently checking homework during lessons with no significant difference between them. Both the student attitude towards mathematics and instructional activities in mathematics class factors show that generally students in both types of schools were positive in their attitude towards the study of mathematics and teachers adopted similar pedagogical practices concerning the consolidation of mathematical concepts and skills that are mainly done in the extended lesson which goes beyond the hours of school into the homes of the students.

The second part of the study shows that only six of the 14 school level variables were found to be significant predictors of mathematics achievement for secondary schools in Singapore. In addition to time spent on homework for mathematics, science and language, serious student misbehaviour and future aspirations of students, classroom environment and teaching experience of mathematics teacher were found to be predictors of mathematics achievement in secondary schools.

## Implications

The findings of this study have several implications for mathematics teachers in Singapore schools. Teachers can help their students excel in the learning of mathematics by ensuring that

- the learning environment is appropriate. Feedback from students can be sought to check for the status of the environment. Teachers may also negotiate with the management of the school for space that is conducive for students to carry out their lessons and mathematical activities.

- students do spend time doing their homework meaningfully. Constant review of homework assignments and occasional dialogue with individual students can help to monitor students' homework.

- students are aware that misbehaviour /disruption in class has adverse effect on their mathematics achievement. An occasional reminder to the class that they must respect the desire of their classmates to utilize class time fruitfully may gently but certainly help to create the awareness.

- students are motivated and have high aspirations. Drawing on examples of students or national heroes who have done well, particularly in mathematics, and gone onto higher education may help to motivate students and raise their aspirations.

- they themselves (the teachers) are constantly enhancing their experience of teaching mathematics through professional development.

## Conclusion

In conclusion, it may be claimed that in Singapore, classrooms with high mathematics achievements have environments conducive for study, experienced mathematics teachers, well disciplined students with high expectations of themselves, high future aspirations and who diligently work through their homework assignments. These classrooms belong to high-achieving schools.

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