

**AN EXPLORATION OF DIFFERENCES IN
MATHEMATICS ACHIEVEMENT IN
SINGAPORE AND THE
UNITED STATES**

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Content analysis of data from the Third International Mathematics and Science Study (TIMSS) and survey data were used to examine the impact of classroom time management, and instructional methods and resources on mathematics achievement in Singapore and the United States. The content analysis was based on TIMSS data from fourth- and eighth-grade students and teachers in the United States, and students and teachers at equivalent grade-levels in Singapore. The survey examined responses to TIMSS questionnaire items from a focus group of current Singapore teachers. In both countries, mathematics instruction was commonly textbook-based and teacher-centered, but US teachers were more prone to emphasize computational and other lower-level thinking skills. Singapore teachers were more apt to spend time in whole class instruction and in activities where students worked individually without assistance. Other differences between the two countries' teachers concerned the amount of homework they assigned, their sources for teaching methods, preparation time, and in-service development. Students whose teachers taught mathematics for 75-100% of their teaching schedules tended to attain TIMSS scores that reflected their country's national averages. There were also indications that US teachers could benefit from professional development on implementing local and state curriculum guidelines.

INTRODUCTION

The wealth of results from the Third International Mathematics and Science Study (TIMSS) and its successor, TIMSS-Repeat (TIMSS-R), include frequent commentaries about the performance by Singapore, one of the smallest countries in the world, yet one of the highest scoring on the comparative studies. Particular references to the mathematics scores of students from Singapore and the United States occur more than 25 times in benchmark documents that compare these national performances (Kelly, Mullis, & Martin, 2000; Mullis, 1997). Moreover, there are more than a dozen references to the mathematics results of the two countries in a recent analysis of national performance in algebra and geometry (US Office of Educational Research and Improvement, 1999).

During the past two decades many bilateral studies have focused on international mathematical comparisons (Phelps, Smith, Alsalam & Sheey, 1996; Travers, Crosswhite, Dossey, Swafford, McKnight & Cooney, 1985). In a number of these studies, researchers have compared the performance of students from the United States to that of students in Asian countries (Stevenson, 1998; Baker, 1993; Westbury, 1992). These comparisons generally indicate that students from countries such as Japan, Korea, Singapore, and China frequently experience great success on tests of mathematics achievement. Moreover, representatives from Asian countries have consistently established themselves as some of the best-trained young mathematicians in the world (Andreescu & Kedlaya, 2000).

TIMSS and TIMSS-R results indicate that Asian countries have continued to perform extremely well on international assessments (Mullis, Martin, Gonzalez, Gregory, Garden, O'Connor, Chrostowski, and Smith, 2000). These results also continue to underscore the need for reform in school mathematics education in the United States. When American students' mathematics performance was tallied, the TIMSS and TIMSS-R results showed that United States' students lagged behind their counterparts in other industrialized countries. The majority of American 17-year olds, for example, could not correctly answer such basic mathematical questions as how to compute the area of a rectangle.

Although at Grade 4 TIMSS and TIMSS-R showed only marginally different achievement results between US and Asian students, the gap widened significantly by Grade 12. Overall, the average score of US Eighth Grade students was somewhat below the international average in mathematics, while the score of the US Twelfth Graders was well below the international average. Closer inspection reveals that the average student performance of 20 countries in Grade 8 mathematics was significantly better than the average performance of US students on TIMSS, and in 13 countries the performance was not significantly different from that of the US students. In the end, the average student performance in mathematics at Grade 8 for US students was significantly better than that of only seven other countries (National Center for Educational Statistics, 2001).

Despite these sobering results, no single coherent vision of how to educate today's students dominates US educational practice in mathematics (Schmidt, McKnight, & Raizen, 1997). Thus, as mathematics educators attempt to improve the mathematical competence of American students, it is important to study the school mathematics programs of the top scoring TIMSS countries. Singapore is the single top scoring country in which the language of instruction is English, and in the US, the mathematics content standards for one of the largest states stipulate that its mathematics curriculum should aim to be comparable to Singapore's curriculum (California Department of Education, 1999).

TIMSS data show that Singaporean Grade 8 students score significantly higher in mathematics than US 8th Graders, while at Grade 4, students from Singapore and the United States are more comparable. Since TIMSS results do not address the rationale for these or other performance differences between students, the present study examines two primary pedagogical considerations that may account for these differences: classroom time management and instructional methodology. Data from the TIMSS achievement tests along with data collected in Singapore from a year 2000 focus group of secondary school teachers were used to relate national differences in instructional and classroom time management practices to mathematics achievement.

PROCEDURES

As Schaub and Baker (1991) maintain in their comparison of Japanese and American mathematical achievement, there is ample support for the contention that differences in resources are not the chief reasons why Singapore students outperform their counterparts in the United States. Instead, the literature on teacher behavior and student achievement (Brophy & Good, 1986) supports the rationale that the schooling process in Singapore classrooms is sufficiently distinct from that in American classrooms to make this process an important and key consideration in exploring achievement differences in mathematics. Consequently, differences in teachers' management of classroom time and their use of instructional methods and resources could provide valuable insight into national differences in mathematics performance. Particularly, this study intended to tap the enormous potential of TIMSS and TIMSS-R data to improve mathematics achievement by exploring the evident relationships of this achievement with classroom time management and instructional methods and resources.

The chief methodology for this investigation was a content analysis of the TIMSS data from both countries. To investigate the relationships of achievement with time and instructional practices, the content analysis was supplemented by survey data from a focus group of 19 Singapore secondary school teachers. As in the studies reported by Kaur (2000), content analysis of TIMSS data was based solely on released data that was publicly available at the TIMSS Web site.

The TIMSS International Study Center at Boston College and the TIMSS International Curriculum Analysis Center at Michigan State University have published reports detailing the results for Singapore and US students in the third and fourth grades (Population 1) and in the Seventh and Eighth Grades (Population 2), as well as background data on both the students and their teachers. These TIMSS Centers have also released, at their Internet Web sites, the international databases that contain all the achievement and background data for countries that participated in TIMSS and TIMSS-R. Due to the magnitude of the databases, this study predominantly focused on student and teacher data from the Fourth Grade in Population 1 and from the Eighth Grade in Population 2.

FINDINGS

The Fourth Grade TIMSS samples consisted of 191 Singaporean teachers and 389 American teachers, as well as 7,139 and 7,296 Fourth Grade students from Singapore and the United States, respectively. At the level of US Grade 8 (Secondary 2 in Singapore), the TIMSS databases contained information from 137 Singapore teachers along with 346 US teachers. Accompanying student databases showed TIMSS scores and other information from 4,644 Singapore and 7,087 American students (Kelly, Mullis, and Martin, 2000).

Overall achievement results for Grade 7 showed the average scores for Singapore and US students were 601 and 476, respectively, while the corresponding respective averages were 643 and 500 for Singaporean and American Grade 8 students. The achievement results for Grade 4 showed the average score of 625 for Singapore and 545 for US students (National Center for Educational Statistics, 1997). These averages indicate the significant performance differences in favor of Singaporean students that were typical of TIMSS and TIMSS-R mathematics scores.

CLASSROOM TIME MANAGEMENT

With respect to the whether Singaporean teachers use class time more efficiently than their US counterparts, several indicators of efficient use of class time were collected and reported in TIMSS. At the fourth grade level, slightly more than 60% of Singapore and US teachers reported that more than half of their teaching time was based on the textbook. For Grade 8 (Secondary 2) teachers, the corresponding figures were 86% for Singapore and 67% for the US. Figure 1 displays these figures along with the percentage of the year 2000 focus group of Singapore secondary school teachers who reported they based more than half their teaching time on the text.

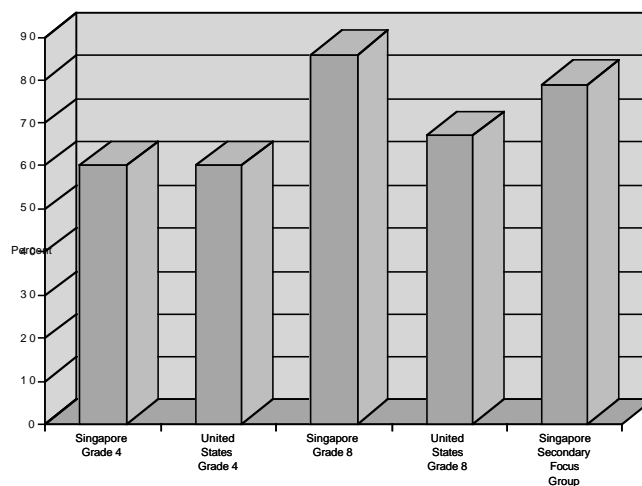


Figure 1: Percentage of Teachers Who Indicated They Based More Than Half Their Teaching Time on the Textbook

A contrasting use of class time was reflected in TIMSS items related to teachers' recent lessons. Forty percent of Singapore 4th Grade teachers and 79% of their US counterparts reported that their most recent class session was used to complete an unfinished lesson. Another contrast concerned the amount of time spent reviewing homework during class time. Singapore Fourth Grade teachers reported spending about 10 minutes, while Eighth Grade Singapore teachers and US teachers in both Grades 4 and 8 reported spending half that much time.

With respect to small group activities, Singapore Fourth and Eighth Grade teachers reported that they spent about 10 minutes on these activities, while US Grade 8 teachers spent about 5 minutes on small group work and more than half the US Fourth Grade teachers indicated they spent no time on small group activities. Twenty-eight percent of Singapore Fourth Grade teachers also denoted that, in most every lesson, they ask students to use tables, charts, or graphs, while 10% of the US teachers indicated accordingly. Thirteen percent of Singaporean Fourth Grade teachers reported that, in class, they asked students to work on problems with no obvious method of solution. Six percent of the US Grade 4 teachers responded similarly on this item. For Eighth Grade teachers, the corresponding figures were 6%

for Singapore and 10% for the US. Figure 2 summarizes these findings along with the percentage of the secondary school focus group respondents who indicated that they ask students to work on problems with no obvious method of solution.

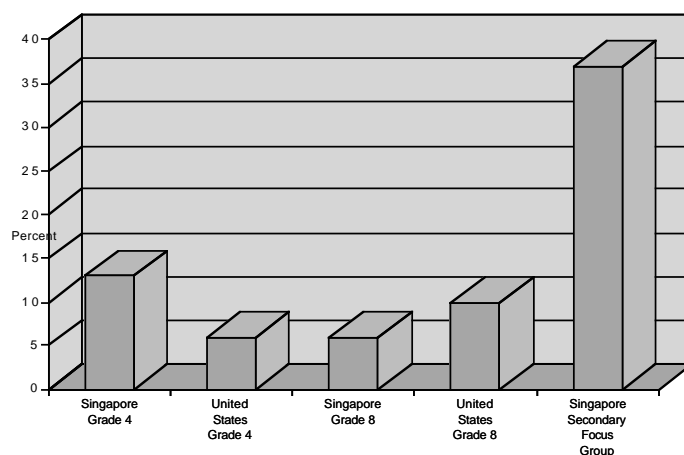


Figure 2: Percentage of Teachers Indicating They Asked Students to Work on Problems With No Obvious Method of Solution

In almost every lesson 67% of the Singapore’s Fourth Grade teachers and 82% of the US teachers stated that they asked students to practice computational skills. The corresponding figures for the Eighth Grade were 50% for Singapore and 59% for the US. Also, in almost every lesson, 37% of Singapore’s Fourth Grade teachers and 55% of the American teachers reported that they have students work individually with assistance during class time. At the Grade 8 level, the corresponding percents were nearly the same for Singapore (48%) and the United States (51%).

In both countries and at both grade levels, the teacher respondents indicated a preference for teacher-centered methods. Sixty-eight percent of Singapore Fourth Grade teachers and 54% of their US counterparts, as well as 61% of Singapore Eighth Grade teachers and 56% of the US Grade 8 teachers, have students work as a class led by the teacher in almost every mathematics lesson.

At both grade levels teachers' reports showed that having students work individually without assistance from their teacher was more popular in Singapore than in the US. Teachers of forty-one percent of the Fourth Grade Singapore students reported that, in most or every lesson, students work individually without assistance from the teacher, while teachers of 15% of the US fourth grade students indicated they used this organizational approach. For the two countries' Eighth Grade teachers, the percents were 27% for Singapore and 19% for the US. Figure 3 summarizes the findings concerning students working individually without teacher assistance for the four TIMSS groups as well as for the Singapore secondary focus group.

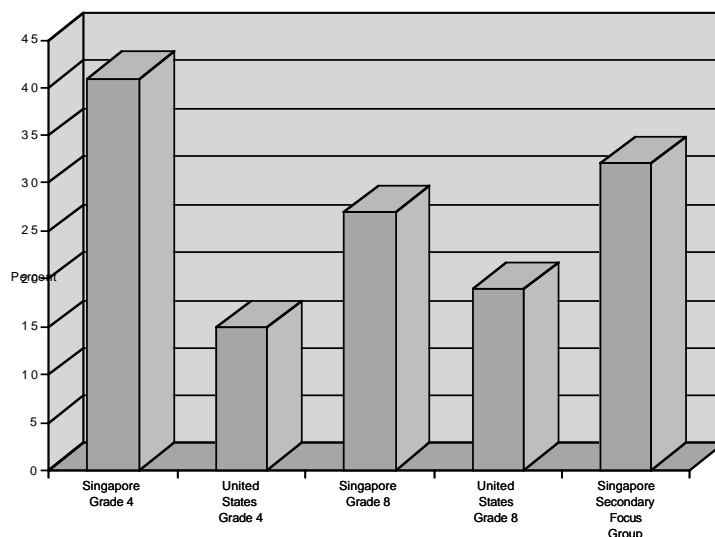


Figure 3: Percentage of Teachers Indicating That in Almost Every Lesson They Have Students Work Individually Without Assistance from the Teacher

TIMSS data also showed that 78% of Singapore Eighth Grade teachers and 62% of their US counterparts reportedly spent more than half of their scheduled time at school actually teaching mathematics. Average achievement scores of Singapore students whose teachers spent 75-100% of scheduled time at school teaching mathematics had mean achievement scores of 630, while the mean achievement scores for US students whose teachers spent 75-100% of their time teaching mathematics was 501.

In TIMSS background questionnaires, fourth grade students were also queried about their teachers' efficient use of class time. During most mathematics lessons, the students' reports indicated that Singapore teachers assigned homework, and then checked and discussed completed assignments more often than did their American counterparts.

Eighth Grade students also completed TIMSS background questionnaires in which they were queried about their teachers' efficient use of class time. During most mathematics lessons, the students' reports indicated that both Singapore and US teachers assigned homework and checked completed assignments. However, the students' reports also indicated that US teachers were twice as likely to spend class time discussing completed homework. Also in most mathematics lessons, the students' responses indicated that US Eighth Grade teachers, like US Fourth Grade teachers, were more apt than their Singapore counterparts to: (1) demonstrate how to do mathematics problems, (2) give quizzes and tests, (3) have their students copy notes from the board, (4) assign class work from worksheets or texts, (5) have their students work on projects or in small groups, (6) have students begin their homework in class, and (7) have students check each others' homework.

METHODS AND RESOURCES FOR INSTRUCTION

The second aspect of the study concerned teachers' incorporation of effective methods and resources for instruction into their classes. Eighty-four percent of Singaporean and 62% of American fourth grade teachers, along with 17% of Singaporean and 51% of US Eighth Grade teachers, reported that the teachers' editions of textbooks were their main sources when deciding how to present a topic. A survey of the secondary school teachers' focus group in Singapore during 2000 showed that about 21% of the mathematics teachers used teachers' editions as their main source for methodology. Figure 4 illustrates these findings on teachers' use of teachers' editions.

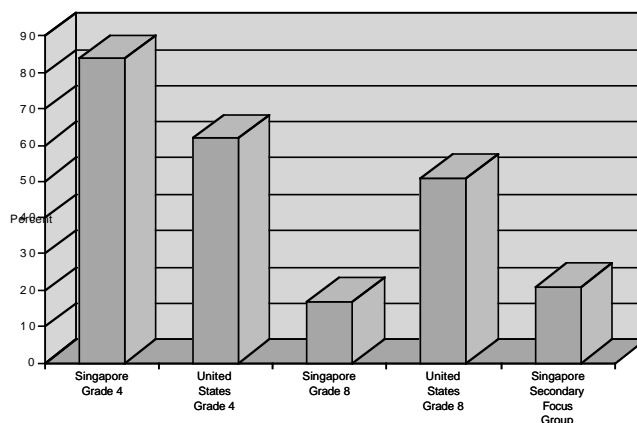


Figure 4: Percentage of Teachers Indicating That Teachers Editions of Textbooks Were Primary Sources for Teaching Methods

TIMSS results also showed:

(1) Singapore Fourth Grade teachers were considerably more likely to have students work individually without assistance in most or every lesson (41% vs. 15%).

(2) Singapore Fourth Grade teachers were also more apt than American teachers to have students work as a class led by the teacher (68% vs. 54%) and to have students work in pairs with assistance (25% vs. 20%).

(3) US Fourth Grade teachers were more likely than Singapore teachers to have students work individually with assistance (55% vs. 37%) or to have students work as a class with students responding to each other (32% vs. 22%).

Overall, TIMSS results also indicated that approximately 85% of the Fourth Grade teachers and 52% of the Eighth Grade teachers from both countries sometimes divided their classes into groups.

Singapore and US teachers also differed in the amount of homework they assigned. For Fourth Grade teachers, 52% of Singaporeans and 7% of Americans assigned 31-60 minutes per class, while in Grade 8, 61% of the Singapore teachers and 23% of the Americans assigned 31-60 minutes of homework per class session. Figure 5 displays these percentages along

with the percent of the focus group of secondary teachers who reported assigning 31-60 minutes of homework per class meeting.

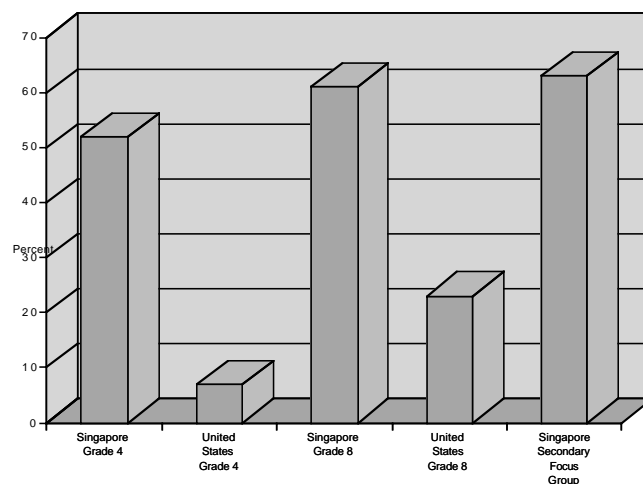


Figure 5: Percentage of Teachers Who Indicated They Assigned 31-60 Minutes of Homework Per Class Session

There were also contrasts between the teachers regarding their knowledge of a national syllabus or national curriculum guidelines for mathematics. Sixty percent of the Singaporean and 16% of US Fourth Grade teachers, along with 75% of the Singaporean and 38% of the US Eighth Grade teachers indicated they were very familiar with national mathematics guidelines or, in the case of the United States, guidelines established by national organizations of teachers.

At Grade 8, 69% of the Singapore teachers and 4% of the US teachers responded that they were very familiar with their school curriculum guidelines, while for Grade 4 teachers the corresponding figures were 68% for Singapore and 55% for the US. Grade 4 teachers also differed in the time spent in personal preparation for classes.

Sixty percent of the Singapore Grade 4 teachers and 32% of their American teacher counterparts replied that they spent more than 3 hours per week outside the school day preparing or grading exams, whereas an equal percentage (15%) of the teachers from both countries stated that they

spent more than 4 hours per day outside of school planning lessons. At the Grade 8 level, Singapore teachers reported they are scheduled for fewer hours to plan their lessons per week (0 vs. 2.4 hours for the US teachers), yet they are scheduled to teach 25% more periods per week (40 vs. 32) than are the American teachers. Also, 57% of Singaporean Eighth Grade teachers indicated that they relied on lesson plans made by the teachers in their school in preparing their own lessons, as compared to only 3% of US Grade 8 teachers.

CONCLUSIONS

Classroom Time Management

The results related to the efficient use of class time indicate that from Grade 4 to Grade 8 both Singapore and US grade teachers increasingly base their teaching on the textbook. However, at Grade 4 approximately the same percentage of teachers (60%) base their teaching on the text. By Grade 8 the results show that the percentage of US teachers has increased to 67%, while the percentage of Singapore teachers has increased to 86%. A review of the survey data from the focus group of secondary school teachers in Singapore showed that 79% reported that they base their teaching on the text. Given the periodic reports of US middle school teachers' inadequate preparation in mathematics (Colwell, 2000), the US Eighth-Grade teachers indicated lack of reliance on the text is a topic worthy of further study.

Another distinction between US and Singapore teachers concerned the TIMSS findings that showed that nearly 80% of the US Fourth Grade teachers spent their most recent class session completing an unfinished lesson. This percentage was twice as large as the corresponding figure for Singapore teachers and may be an indication that US Fourth Grade teachers have difficulty maintaining the pace specified in curriculum guidelines.

The time spent by both countries' teachers in reviewing homework showed a contrast at Grade 4 where US teachers spent half the time (5 minutes) that Singapore teachers usually spent in this review. This finding may indicate that US teachers assign less homework or less demanding assignments at Grade 4.

Another contrast in the TIMSS responses showed that at Grade 4 more than twice as many Singapore teachers (13%) reported asking students to

work on problems that have no obvious method of solution. Notably, the situation was reversed at Grade 8, where twice as many Americans (10%) spent class time on nonroutine problems. A survey of the 19 teachers in the Singapore 2000 focus group found that seven of the 19 had spent class time on problems with no obvious method of solution during the past two weeks. Nevertheless, the Grade 4 percentages may be an indication that these US teachers should be allotting more time to nonroutine problem solving.

TIMSS results also showed that American teachers at both grade levels spent more class time having students practice computational procedures. In order to make more efficient use of class time, these results suggest that US teachers may need to emphasize higher level thinking in mathematics in lieu of computational practice.

The findings of this study also show that Singapore teachers were more apt to have students work as a class with the teacher leading, and to have students work individually without any assistance (Figure 3). At the Fourth Grade level nearly three times as many Singapore teachers as American teachers reportedly had students work individually without assistance from the teacher in almost every lesson. This use of classroom time was also more popular with Singapore Grade 8 teachers as compared to US Eighth Grade teachers, although the difference (27% vs. 19%) was less pronounced.

Based on the mean TIMSS scores of students whose teachers taught mathematics 75-100% of their teaching time, it appears that this TIMSS variable may serve as a predictor of students' performance on the TIMSS achievement tests. Actual mean TIMSS scores for Grade 8 students (Singapore 643; US 500) were close to the mean scores for those students whose teachers taught mathematics for 75-100% of their time at school (Singapore 630; US 501). Notably, in the follow-up survey of current Singapore teachers in the secondary school focus group, nearly three-fourths of the teachers reported that they taught mathematics 75-100% of their time at school.

The results of the Eighth Grade students' TIMSS questionnaire items on teachers' use of class time, showed an inconsistency when compared with teachers' reports of how much time they spent discussing completed homework. In particular, US students' questionnaire items indicated that US teachers were twice as likely to spend class time discussing homework

as their Singapore colleagues. However, the Singapore and US Eighth Grade teachers' reports both indicated that they spent about the same amount of time (five minutes) discussing homework in each lesson. At the Fourth Grade level there was consistency between the teachers' and students' reports concerning the amount of time that was spent discussing completed homework assignments. Specifically, Singapore Fourth Grade teachers appeared to have been more apt to discuss assigned homework than their American counterparts.

Data from TIMSS student background questionnaires reinforced findings that US teachers were also more likely to spend class time in a number of activities that are often regarded as efficient uses of time. Particular examples include: (1) demonstrating how to do mathematics problems, and (2) assessing achievement. However, the TIMSS findings that US teachers were more apt to engage in the above activities may be questioned since, in year 2000, all of the 19 secondary mathematics teachers surveyed in the Singapore focus group reported that assessing student achievement and demonstrating how to do a mathematics problem were indeed good uses of class time.

METHODS AND RESOURCES FOR INSTRUCTION

With respect to teachers' incorporation of effective methods and resources for instruction, the TIMSS data supports the conclusion that, although both countries' teachers rely heavily on teachers' editions in Grade 4, more Singaporean Fourth Grade teachers use the teachers' edition of the text as main sources for determining methodology. At Grade 8, relatively few of the teachers from Singapore (17%) use the teachers editions as the primary source for teaching methods, however more than four times as great a percentage (81%) of US teachers rely on the textbooks as their chief source for methods. This difference between US and Singaporean Eighth-Grade teachers is a major distinguishing characteristic and, as such, may shed some insight into the differences in TIMSS scores. The year 2000 survey data from the Singapore secondary school mathematics focus group showed that 15 or 79% of the respondents commonly used resource books or teacher-made lesson plans as their primary sources for teaching methods. Further study appears warranted of the heavy reliance by US eighth grade teachers on teachers' editions and by Singapore eighth grade teachers on resource books or teacher-made lesson plans.

Another major difference between Singapore and US mathematics teachers concerns the formers' propensity to have students work individually without assistance, or to have students work in pairs with assistance, or to have students work as a class with the teacher leading. Alternatively, the TIMSS data indicated that American teachers were more likely to have students work individually with assistance or to have students work as a class with students responding to each other. Except for Singapore Grade 4 teachers' greater tendencies to have students work individually without assistance, it is evident from the findings that teachers from both countries use a variety of grouping strategies for instruction. That is, based on the findings from this study, the use of groups as a teaching methodology does not appear to differentiate between Singapore and US teachers.

However, the amount of homework assigned did appear to differentiate between the teachers in the two countries. In particular, the amount of homework assigned by Singapore teachers was substantially more than that assigned by US teachers, and the assignment of 31-60 minutes of homework could serve as a major means to distinguish the two countries' mathematics teaching. In an effort to confirm these findings, the survey of the focus group of secondary mathematics teachers in Singapore found that 63% assigned 31-60 minutes of homework per night. Consequently, to improve performance by US students on tests like the TIMSS achievement instruments, consideration may also need to be given to increasing the amount of mathematics homework assigned at both the 4th and 8th Grades.

American teachers at both Grades 4 and 8 indicated they received less in-service professional development than their Singaporean colleagues. In particular the finding that substantially fewer US teachers are familiar with national curricular guidelines suggests that these national guidelines might serve as an organizational theme for increasing in-service for US teachers. The differences between the 4th Grade teachers in their knowledge of school curricular guidelines, and particularly the finding that 4% of US Grade 8 were familiar with the school guidelines, indicate that these US teachers would benefit from increased in-service on these local guidelines and on state curriculum frameworks as well.

The difference in the amount of time the teachers spent in preparing and grading exams was another aspect of preparation that distinguished

the two countries' 4th Grade teachers. As compared to the US sample, roughly twice as many Singapore Grade 4 teachers indicated they spent 3 or more hours per week outside of school on these tasks. An investigation into these differences may lead to further insights for improving US students' performance on future international comparisons.

Some final considerations for improving international achievement scores relate to the scheduled preparation time of Eighth-Grade teachers and use of in-school, teacher-prepared lesson plans. US teachers' responses to the TIMSS items indicated they have more preparation time, fewer classes to teach, smaller class sizes, and they use lesson plans prepared by colleagues much less frequently than their Eighth-Grade teaching counterparts in Singapore. Future investigations of the benefits to be gained from greater use of in-school lesson plans and fewer teachers assigned to duties outside their major field of preparation are apt to provide further insights about improving mathematics achievement on international comparisons.

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