The Mathematics Educator
1998, Vol. 3, No. 2, 88-99

How Do Japanese, American, And Singaporean Primary School Mathematics Teachers Teach

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Introduction

The conventional wisdom has it that Mathematics is a universal subject that transcends national boundaries. This implies that the subject matter of Mathematics does not vary much across nations. At the school level today, there are discrepancies as shown by recent research, not only in terms of content but also pedagogy. This paper gathers examples of such studies to illustrate the variation and hopes to interest the readers in thinking about such cross-national differences and their implications for mathematics education and mathematics educators.

America-Japan Comparison

In the first two IEA's international studies of Mathematics, Japan topped the list of the participating nations and America was far behind (Husen, 1967; Robitaille & Garden, 1989). This was surprising enough to trigger off a keen cross-national research on mathematics teaching. Joint projects were then conceived and conducted to find out what different factors there are that might have made the difference in achievement. The study by Lee, Graham and Stevenson (1996) is typical of such studies.

Lee et al.'s (1996) study involved 10 Japanese elementary schools in Sendai, representing a broad range of schools in a large, traditional Japanese city, and 20 American elementary schools in the Chicago area, representing the diverse ethnic, racial, and socio-economic groups residing in the metropolitan area. Classroom observations were carried out by local college or graduate students who were first trained to use a time-sampling method and recorded the presence or absence of predetermined categories of teacher and student behaviours. Training ceased when a 80% inter-rater agreement was attained. Classroom observations were then carried out four times over two in each classroom.

Table 1. Comparisons between American and Japanese Mathematics Teaching

Observations	Japanese	American
Teacher qualification		
Master's degree	-	100
Bachelor's degree	78	40
Classroom organisation		
Whole-class teaching	95	82
Attending to the teachers or on task	80	60
Single-topic coherent lessons	89	30
Student providing answers or explanations	99	88
Group discussion on solutions	17	1
Teaching methods		
Use of concrete objects	44	32
Visual presentation	60	38
Use of drill	6	17
No explanations by teachers or students	1	12
Conceptual information	67	30
Procedural information	92	98
Meaningful context	70	28
Application of concept to different problems	46	30
Elaboration of student's answer	45	14
Relating to abstract concepts	51	18
Students proposed alternative approaches to problems	31	9
Seatwork		
Assigned	90	85
Discussed as part of the lesson for immediate feedback	85	50
Evaluation		
By teacher	70	47
By student(s)	59	31

Note: All figures are percentages. The table is a reconstruction of information in Lee, Graham, & Stevenson (1996). The figures in table are approximations. For simpler presentation, where two figures are available for grades one and five, the average is taken.

Table 1 shows the comparisons between the American and the Japanese samples on teacher qualification, classroom organisation, teaching methods, seat work, and evaluation. What can be deduced from these information? The following differences are observed:

1. ***Teacher Qualification.*** American teachers were far better equipped where academic qualification is concerned.

2. ***Classroom Organisation.*** Japanese teachers were better organised. When compared with their American counterparts, Japanese teachers used a combination of whole-class teaching and group learning. They were better at maintaining student attention and involvement through clearly focused lessons.

3. ***Teaching behaviours.*** More Japanese teachers used concrete objects and visual presentation, worked on conceptual understanding and meanings, built on students' responses and engage students in looking for solutions, and emphasised application and referencing.

4. ***Seatwork.*** In the Japanese classrooms, seatwork was a functional part of the lessons and immediate feedback was more readily available. Moreover, both teacher and student evaluation were more popular in the Japanese than in the American classrooms.

In sum, Japanese teachers were task-driven, better organised, concerned with understanding, and teacher-centred but balanced with sufficient student involvement. These conjure up in one's mind a somewhat regimented classroom where students are constantly kept engaged through meaningful activities and where both verbal and visual presentation prevails.

American-Chinese Comparison

For wide coverage of content, international studies use, by necessity, closed-ended multiple-choice items to assess students' mathematics performance. The differential performances of the participating nations show only the quantitative differences across nations. A pertinent question to ask is, then, ***Do students think qualitatively differently in mathematics, too?*** Research on qualitative differences in mathematical thinking has been vigorously pursued in

Cross-national difference was also found in a number theory problem:

> *I used blocks in my math class toady. When I grouped the blocks in groups of 2, I had 1 block left over. When I grouped the blocks in groups of 3, I had 1 block left over. And when I grouped the blocks in groups of 4, I still had 1 block left over. How many blocks did I have?* (Adapted from Cai)

The answer to this is any number that satisfies 1+12n where n=1, 2,...For this problems, Cai found (a) correct answers were given by 56% American and 54% Chinese students, (b) a large number of both samples gave answers beyond 13, with 25 the most frequent one, and (c) a few Chinese students even gave a general form for the infinite number of correct answers. The students' explanations for the solutions were coded as verbal (using words), visual (using drawing), or symbolic (using mathematical expression). Comparisons show:

1. American students to be more verbal (39%) than Chinese students (15%)
2. Chinese students are more symbolic (84%) and American students (44%)
3. Both samples were least visual but there is still a difference between the American (17%) than Chinese (1%) students.

Cai's (1997) findings pointed out that cross-national differences in mathematical performance are not only quantitative but also qualitative.

Third International Study

In the Third International Mathematics and Science Studies (***TIMSS***), Singapore topped the list of mathematics achievement, at the fourth grade level, followed by Korea and then Japan. America came in the seventh place among 26 participating countries (Mullis, MARTIN, Beaton, Gonzalez, Kelly, and Smith, 1997). This unexpected surprise has generated a keen interest in Singapore's education and some interesting comments in the States.

The ***TIMSS*** report provides informative database for a better understanding of the factors (or, at least, the correlates) of mathematics teaching and achievement in a cross-national context. Hence, relevant figures were extracted for comparisons between America, Japan, and Singapore.

Table 3. Comparisons of America, Japan, and Singapore on Demographic Characteristics

Demographic Characteristics	**America**	**Japan**	**Singapore**
Populations size (1,000)	260650.00	124961.00	2930.00
Population density	7.56	29.63	4635.48
% Population in urban	76.00	77.50	100.00
GNP per capita (U$)	25860.00	34360.00	23360.00
% school-aged in secondary school	97.00	96.00	84.00
Expenditure on levels 1 & 2 education as % GNP	4.02	2.82	3.38
Expenditure on education (Intl $ per capita)	1040.00	602.00	724.00

Demographic Characteristics. As shown in Table 3, in spite of the vast differences in population size, population density, and percent urban population, the variation in educational expenditure does not seem to be great. However, while America and Japan have more than 95% school-aged young people in secondary schools, on 84% are in Singapore. This difference has been cited as an explanatory factor for the better performance of Singapore over America.

Achievement by Topics. Table 4 shows the performance in specific mathematics topics. Here, Japan outperformed American in almost all topics except in geometry, and Singapore did somewhat better than Japan in several topics, most notably in fraction and proportionality. The achievement profiles of Japan and Singapore are highly similar (Spearman's correlation 0.873, $p<0.05$). The America-Japan correlation (0.735) and the American-Singapore correlation (0.582) are not statistically significant.

Table 4. Comparisons of America, Japan, and Singapore on TIMSS Achievement Variables

Variables	America	Japan	Singapore
Mean (113 items, scaled to mean 500, SD 100)	545	597	625
Overall maths	63	74	76
Whole number	71	82	83
Fraction & proportionality	51	65	74
Measurement, estimation, & number sense	53	72	67
Data presentation, analysis, & probability	73	79	81
Geometry	71	72	72
Pattern, relations, & functions	66	76	76
Test-curriculum match %	63	74	76

Note: Figures in table are scores unless otherwise specified.

In a separate analysis of the data for three G7 countries (USA, UK, and Canada) and three 'Little Dragons" (Hong Kong, Korea, and Singapore), achievement in geometry has no significant correlations with those in all the other topics, which have very high correlations among them (Table 5).

Table 5. Correlations of TIMSS Achievement Variables

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

Note: Countries included in this analysis are USA, UK, Canada, Hong Kong, Korea, and Singapore.

* For df=4, r=0.729, p<0.05, one-tailed test.

Table 6. Comparisons of America, Japan, and Singapore on TIMSS Teacher Variables

Variables	America	Japan	Singapore
Students taught by male Maths teachers	14	39	18
Hours/week marking tests & student work	5.4	5.4	7.4
Hours/week meeting students outside class	0.9	1.3	2.3
Average number of students per class	24	32	39
Whole-class teaching	54	78	68
Group/pair work with teacher assistance	20	7	25
Practice of computational skills	54		45
Practice of reasoning skills	66	46	52
Homework (3 or more time, up to 30 minutes)	49	57	39

Note: Figures in table are percentages unless otherwise specified.

Teacher Variables. Table 6 enables cross-national comparisons in teacher variables in term of what teachers did in mathematics lessons. It is obvious that Singapore teachers spend more time than their Japan and American counterparts marking student work and providing out-of-class coaching. Although the ratio between whole-class teaching to group-pair work is the same (2.7) for American and Singapore, greater proportion of Singapore teacher engage themselves in these two teaching strategies, notwithstanding the much larger number of students they have to handle. It is also interesting to note that a smaller proportion of Singapore, compared with their American counterparts, indicate using practice of computational skills and reasoning as well as homework. On the other hand, Japan teachers seem to rely much more than do Singapore teachers on whole-class teaching and homework.

In sum, Singapore teachers give the impression that they spend more time ***on, with, and for*** their students. Perhaps, it is such direct commitment that has propelled Singapore students to the height of mathematics achievement internationally.

Table 7. Comparisons of America, Japan, and Singapore on TIMSS Student Variables

Variables	America	Japan	Singapore
Have dictionary, study desk, & computer	49	-	40
Speaking test language at home	85	-	20
Self: Doing maths well is important	98	75	98
Self: Have time for fun is important	94	94	57
Mother: Doing maths well is important	98	-	96
Mother: Have time for fun is important	88	-	46
Friends: Doing maths well is important	72	70	94
Friends: Have time for fun is important	95	92	65
Homework (1 hour or more on school day)	32	31	-
Self-perception: usually do well in maths	44	12	31
Like maths a lot	50	24	52
Strong positive attitude to maths	44	18	49

Note: Figures in table are percentages.

Student Variables. Table 7 shows the responses to a student survey covering both personal and social influences. American students were obviously more motivated to learn mathematics than were Japanese students. When compared with American students, Singapore students were equally motivated, if not more.

One glaring difference between Singapore students and their American and Japanese counterparts is that a much ***smaller*** proportion of Singapore students though "Having time to have fun is important." They also thought that their mothers and friends also thought likewise. It is interesting to note that, in a separate analysis mentioned above, the attitude that "Having time to have fun is important" show statistically significant ***negative*** correlations with achievement, not only for self's attitude (-0.876, $p<0.05$) but also for perceived mother's attitude (-0.784, $p<0.05$) and perceived friends' attitude (-0.861). This could well be a reflection of Singapore's task-oriented culture, not only among the adults but among youngsters as well. It also underlines the effect of social pressure in time-use, which has long been recognised as a crucial factor in effective learning (e.g., in the Masterly Learning Model and other time-on-task studies).

American Responses to TIMSS. Although America did not come up top in the international studies, they show sportsmanship in that they were able to take a critical look at themselves. Here are some official comments, culled from the Internet, which have lessons for us.

On competition:

> *If we see the news in the report as simply a horse race of who finished first and who finished second we miss the point. The issues are much deeper -- the content and rigor of what we are teaching – how we go about teaching – the fact that we continue to shortchange America's teachers by not giving them the preparation and help they need to do the best job possible in the classroom. One of the clear messages of this report is that we need to take a good, hard look at what we teach and how we teach math," (Richard W. Riley, US Secretary of Education)*

On curriculum:

> *Currently, US standards are unfocused and aimed at the lowest common denominators. In other words, they are a mile wide and an inch deep....This unfocused approach reflects the fragmented nature of the educational system in the US....and the lack of common standards on what to teach and how to teach it....The achievements of students in other nations reflect the benefits of coherent goals and firmly grounded teaching practices.*

On teaching:

> *A US mathematics teacher's typical goal is to teach students the mechanics of solving a problem versus understanding the concepts behind it, while a Japanese teacher's goad is to help them learn the basics as well as understand the relevant mathematical concepts....In Japan, students are asked to solve problems, present them to the class, and describe how they approached the problem to increase their own understanding.*

> *The US expects less of its middle school students compared to high performance nations....the mathematics curriculum in the US is significantly less challenging....In Germany and Japan, virtually all students in grades 5 through 8 move beyond arithmetic to the foundations of algebra and geometry....while in US only students in college-preparatory classes receive significant exposure to algebra, and very few students study geometry.*

Conclusion

Now that we have another *international first*, what do we go from here? Are we going to rest on our laurels? We need to take a closer look at factors that might have contributed to our achievement and further strengthen them so that we can do better next time, not so much in comparison to other nations but our own. Reflecting on the findings of the studied cited here, we need to be aware of the possible effects of culture on cognitive and affective aspects of learning in terms of modes of thinking and social motivation through parents (especially the mother) and the mutual influence of peers..

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