MATHEMATICS EDUCATION IN EAST ASIA AND THE WEST[1]: DOES CULTURE MATTER?

LEUNG Koon Shing Frederick
The University of Hong Kong

1. INTRODUCTION

Students in East Asia outperformed their counterparts in the West in large-scale international studies of mathematics achievement. For example, the top-ranking countries[2] in the Third International Mathematics and Science Study (TIMSS) in 1995 (Beaton *et al*, 1996; Mullis *et al*, 1997), its repeated study in 1999 (TIMSS-R or TIMSS 1999) (Mullis *et al*, 2000), and the succeeding trend study in 2003 (TIMSS 2003) (Mullis *et al*, 2004) as well as the OECD Programme for International Student Assessment (PISA) studies in 2000, 2001 and 2003 are all East Asian ones (OECD, 2001, 2003, 2004). These results are consistent with those of earlier studies (for example, Second International Mathematics Study (SIMS) (Robitaille and Garden, 1989), International Assessment of Educational Progress (IAEP) (Lapointe

[1] In this paper, East Asia refers to countries or education systems such as China, Hong Kong, Japan, Korea, Taiwan and Singapore, and the "West" refers to countries in North America, Europe and Australia. Here "East" and "West" are cultural rather than geographic demarcations, with the Chinese or Confucian tradition in the East and the Greek/Latin/ Christian tradition in the West. We acknowledge that neither of these "poles" is well defined, as with any label given to any culture. But we use the two terms to point to the scope that we want to confine ourselves to in this chapter.

[2] While some education systems (e.g. Hong Kong) participating in these international studies are not countries, the generic term "countries" will be used as a convenient way to refer to all participants.

et al, 1992), and a study by Stevenson and Stigler (Stevenson *et al*, 1990, 1993), and it seems that the superior performance of East Asian students is rather stable over time.

How do we account for the superior performance of East Asian students? Student achievement is enmeshed in a host of variables at different levels, and international comparative studies in achievement should prompt us to identify similarities and differences in educational practices, understand the different traditions underlying the different practices, and seek to explain the similarities and differences. In explaining differences, the crucial question to ask is "what matters?" That is, of the variables construed to be related to student achievement, which of them actually show a pattern that matches with that of student achievement in international comparative studies?

In this paper, we will look at a number of variables including societal resources, characteristics of the education system, and teacher attitudes and attributes in order to identify whether there are any patterns that can be matched with the pattern of student achievement. Finally, we will examine the underlying cultural values in East Asia to see whether they can be used to account for the superior performance of the East Asian students.

2. EAST ASIAN STUDENTS' MATHEMATICS ACHIEVEMENT IN TIMSS-R

The high achievement of East Asian students is best illustrated by their results in TIMSS-R (Mullis *et al*, 2000). There were only five East Asian countries (namely Chinese Taipei, Hong Kong, Japan, Korea and Singapore) in TIMSS-R, but they topped the 38 countries in grade eight mathematics (see Figure 1). Furthermore, the difference in the level of achievement between these high performing countries and many of the other TIMSS-R countries was rather substantial. All the five countries were more than three standard deviations above the lowest scoring country, and more than one standard deviation above 15 of the countries.

3. STUDENTS' ATTITUDES TOWARDS MATHEMATICS

Students' achievement in mathematics is usually highly correlated with a positive attitude towards mathematics (Hammouri, 2004; Ma and Kishor, 1997; McLeod, 1992). However, in international studies of mathematics achievement, the superior performance of the East Asian students did not

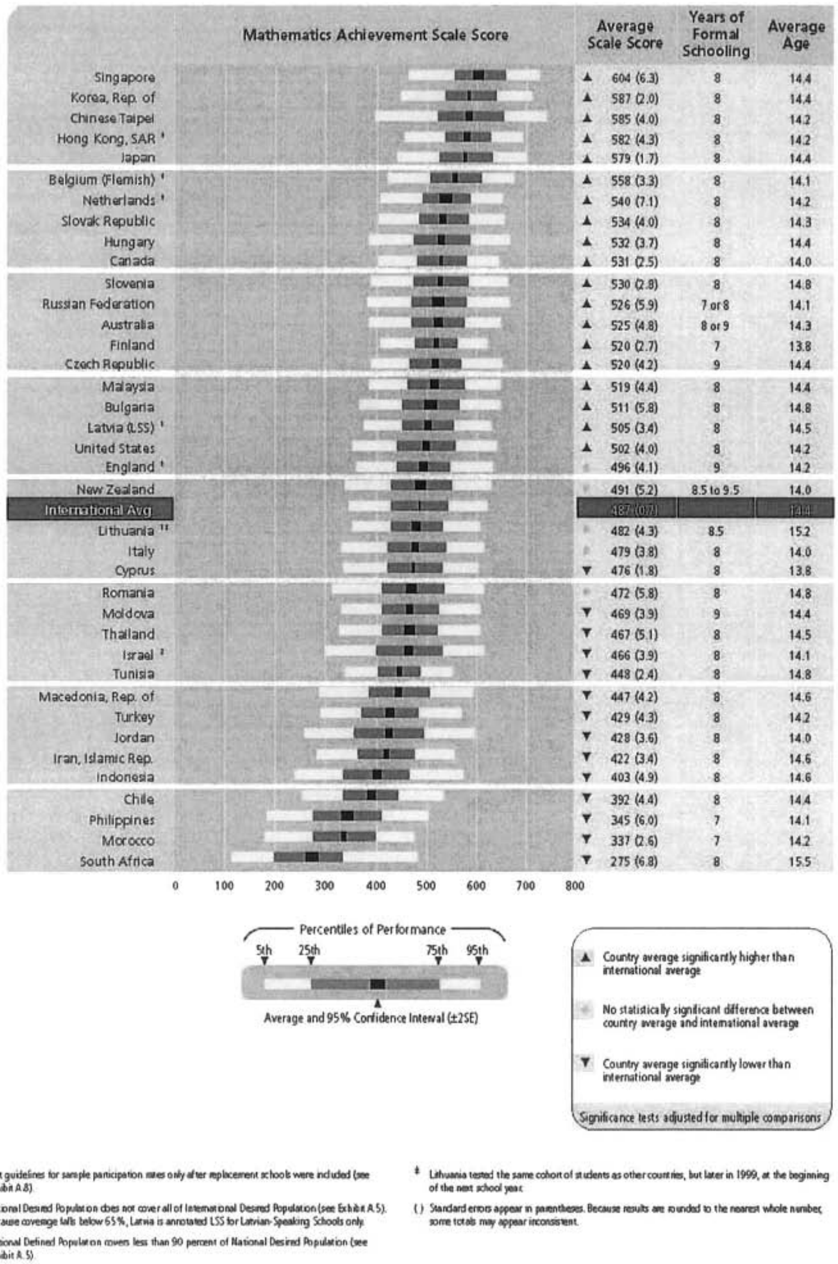

Figure -1. Distribution of TIMSS-R Mathematics Achievement
(Adopted from TIMSS 1999 International Report by Mullis et al, 2000)

seem to be accompanied by correspondingly positive student attitudes towards mathematics and mathematics learning. In the PISA study, for example, Korean students' mean score in the "index of interest in mathematics" is -0.27, which is the lowest among all the PISA 2000 countries[3] (OECD, 2001: 266). This is consistent with the findings from the TIMSS-R student questionnaire, as discussed below.

3.1 The importance of mathematics

The TIMSS-R results show that students all over the world attached a lot of importance to mathematics. In no country was there less than 88% of the students who thought that it was important to do well in mathematics, and the average percentage of students across all the 38 TIMSS-R countries who agreed that it was important to do well in mathematics was 96%. Figure 2 shows students' report on "whether it is important to do well in mathematics" for a selected number of countries[4]. Relatively speaking, we can see that students in East Asia attached less importance to mathematics. Four of the five East Asian countries (with the exception being Singapore) were below the international average of 96%, and Japan, Chinese Taipei and Korea were actually the three countries with the least number of students who thought that mathematics was important.

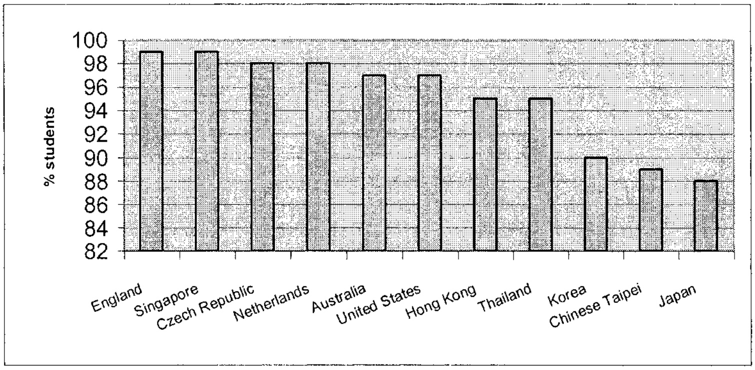

Figure -2. Students' Report on Whether It is Important to do Well in Mathematics (International Avg.=96% of Students)

[3] Korea and Japan are the only two East Asian countries which participated in PISA 2000, but data on the index of interest in mathematics for Japan was not available.

[4] Since there are so many TIMSS-R countries, this selected group of countries will be used for data presentation in this chapter. The international averages cited, however, are the averages for all the 38 TIMSS-R countries.

3.2 Positive attitudes towards mathematics

To bring up students with a positive attitude towards mathematics is a common goal in the mathematics curriculum of many countries, and a positive attitude towards the subject is usually highly correlated with achievement. TIMSS-R developed an index of positive attitudes towards mathematics based on a number of questions in the student questionnaire, and the results for some of the TIMSS-R countries are shown in Figure 3. As can be seen in Figure 3, students in East Asian countries (again with the exception of Singapore) were below the international norm in terms of positive attitudes towards mathematics.

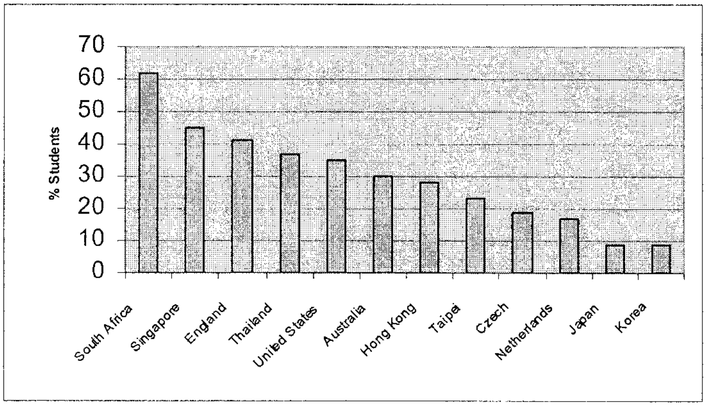

Figure -3. (International Avg.=37% of Students)

3.3 Self-concept in mathematics

In addition to the index of positive attitudes towards mathematics, TIMSS-R also developed an index of students' self-concept in mathematics. The index reflects students' confidence in their ability in mathematics. From Figure 4, it can be seen that students in the East Asian countries, including Singapore, all had self-concept in mathematics lower than the international average.

From the results presented above, it is not difficult to conclude that East Asian students' superior achievements were not accompanied by correspondingly positive attitudes towards mathematics. How do we account for such superior achievement and yet negative attitudes? In the sections below, we will look at variables of different levels from the results of the TIMSS-R questionnaire and other studies in order to seek some understanding of the phenomenon.

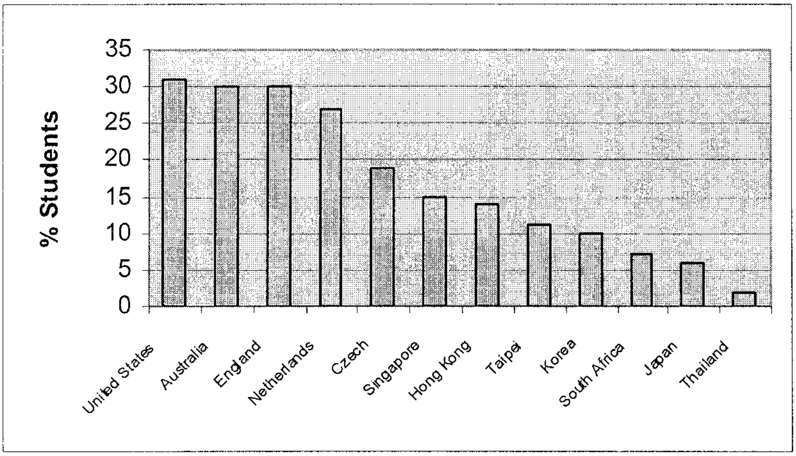

Figure -4. Students' Self-Concept in Mathematics
(International Avg.=18% of Students)

4. SOCIETAL RESOURCES

Whenever a country wants to improve student achievement, a common strategy is to put in more resources. This is based on an assumption or belief that somehow student achievement should be positively related to the resources put into education. Indeed, within a country, academic achievement is usually found to be highly correlated with the social and economic status (SES) of the student. At the international level, can the superior performance of East Asian countries be explained by their wealth or by the resources they put into education?

4.1 The wealth of a country

As can be seen from Table 1, the East Asian countries in TIMSS-R were indeed relatively affluent countries among the TIMSS-R countries. But it should be noted that there were many other affluent countries in TIMSS-R which did not do well in mathematics. So the wealth of a country alone does not guarantee that its students will perform well.

Table -1. GNP per Capita (1999)

Country	GNP per Capita
Japan	US$38,160
Singapore	US$32,810
United States	US$29,080
Hong Kong	US$25,200
Australia	US$20,650
Canada	US$19,640
Chinese Taipei	US$13,235
Korea	US$10,550
TIMSS-R countries average	**US$10,584**

4.2 Education expenditure

Although the East Asian countries were relatively affluent, the amount of money they put into basic education was not particularly high. As can be seen from Table 2, all of these East Asian countries were below the international average in public expenditure on basic education spending as measured by percentage of GNP. Of course the expenditure of East Asian countries in absolute terms might not be low compared to those countries with low GNP. But note that there were wealthy Western countries with high GNP, which also invested a higher percentage of their GNP to basic education, and yet their achievement in mathematics was low compared to the East Asian countries.

Table -2. Education Expenditure

Country	% of GNP
Canada	6.9%
Australia	5.5%
United States	5.4%
Chinese Taipei	4.9%
Korea	3.7%
Japan	3.6%
Singapore	3.0%
Hong Kong	2.9%
TIMSS-R countries average	**5.1%**

4.3 Educational resources

Education expenditure only reflects the amount of money governments in different countries allocated to education. Whether the allocated money results in adequate resources available for mathematics instruction in the schools is another matter. Furthermore, in many countries, private resources are additionally provided at home to support the education of children. Since East Asian parents are known for their emphasis on the education of their children, it will be of interest to see whether East Asian students have better educational resources compared to students in other parts of the world.

The TIMSS-R questionnaire results show that school resources for mathematics instruction varied in these East Asian countries (Mullis *et al*, 2000: 229-233), but surprisingly, home educational resources for East Asian students were in general unfavourable (see Figure 5).

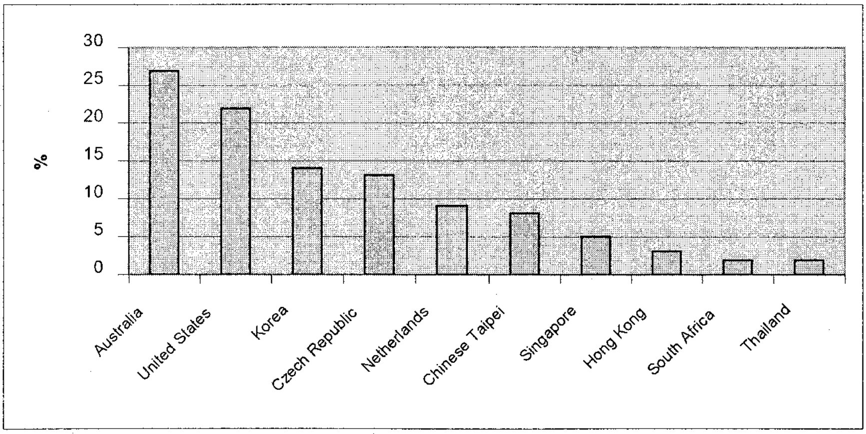

Figure -5. Home Educational Resources (International Avg.= 9%)

From the discussions above, we can see that variables due to societal resources which usually explain within-country differences in achievement fail to explain across-country differences in achievement as far as these East Asian countries are concerned. In fact, from the findings shown above, we can say that societal resources for education are relatively unfavourable in the East Asian countries.

5. CHARACTERISTICS OF THE EDUCATION SYSTEM

If East Asian countries are not better resourced in education, is the high achievement of their students due to a more efficient education system or a better designed curriculum?

5.1 The education system and the curriculum

A common characteristic of all East Asian education systems is that they are highly centralized, and one may argue that centralization increases efficiency. But the TIMSS-R results show that actually many Western systems were also highly centralized (Mullis *et al*, 2000: 148-9), and hence it is unlikely that it is the efficiency of a centralized system that produces high achieving students.

Nor is it likely that the high achievement is due to differences in the content of the curriculum. Actually, the mathematics curriculum is very similar worldwide (Howson and Wilson, 1986), although it is reported that the curriculum content is more demanding in East Asian countries (Silver, 1998; Stigler and Hiebert, 1999).

5.2 Time spent on mathematics instruction

A more demanding curriculum, however, does not necessarily imply that more curricular time is spent on mathematics instruction. The TIMSS-R results show that East Asian countries did not devote a lot of time to mathematics instruction (Figure 6). Except for Hong Kong, all the East Asian countries spent less time on mathematics instruction per year than the international average of 129 hours.

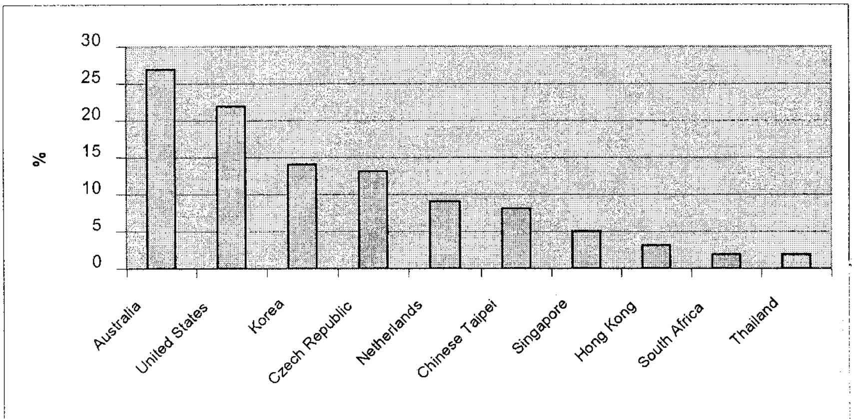

Figure -6. Hours of Mathematics Instruction per Year
(International Avg.=129 Hours)

5.3 Out-of-school time studying mathematics

Although East Asian countries did not devote particularly more time to mathematics instruction in schools, there is a common perception that their students spend a lot of time outside regular schooling studying mathematics. This however is not supported by the TIMSS-R data, which show that East Asian students did not spend more time than their Western counterparts out of school studying mathematics or doing mathematics homework[5] (Figure 7).

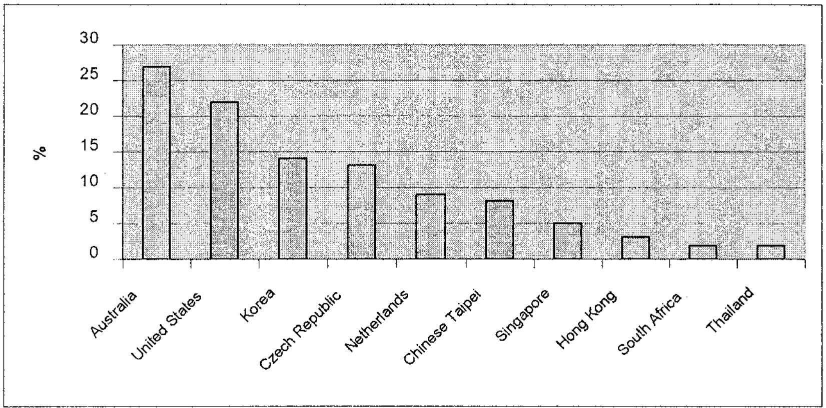

Figure -7. Out-of-School Time Studying or Doing Mathematics Homework (International Avg.=1.1 Hours per Day)

To sum up, we find that the variables at the level of the education system cited above fail to explain the high achievement of East Asian students as well.

6. TEACHER ATTITUDES AND ATTRIBUTES

Since students learn most of their mathematics from their teachers in the classroom, it is reasonable to conjecture that student achievement is related to the quality of the teachers and their teaching. An effective teacher is often thought to be one who is confident in her teaching, who holds a positive attitude towards the subject that she teaches, who employs appropriate teaching methods, and who is competent in the subject matter. Is the high achievement of East Asian students due to the fact that they are taught by a more confident and competent teaching force, employing better teaching methods?

[5] There may be different interpretations of what "out of school" means in different countries, and so the results on time spent out of school should be interpreted with care.

6.1 Teacher attitudes towards mathematics and mathematics education

In a comparative study conducted by the author (Leung, 1992), a questionnaire on attitudes and beliefs in mathematics and mathematics education was administered to about 900 junior secondary school mathematics teachers from Beijing, Hong Kong and London. Results and issues pertaining to the theme of this paper will be discussed below.

6.1.1 Attitudes towards mathematics

In the questionnaire, the SIMS *Mathematics as a Process* scale (Robitaille and Garden, 1989:199) was used to measure "the extent to which (teachers) view the discipline (of mathematics) as rule-oriented or heuristic, as fixed or changing, and as a good field for creative endeavour or not" (Robitaille and Garden, 1989, p.199). The attitudes of teachers from the three cities are shown in Figure 8.

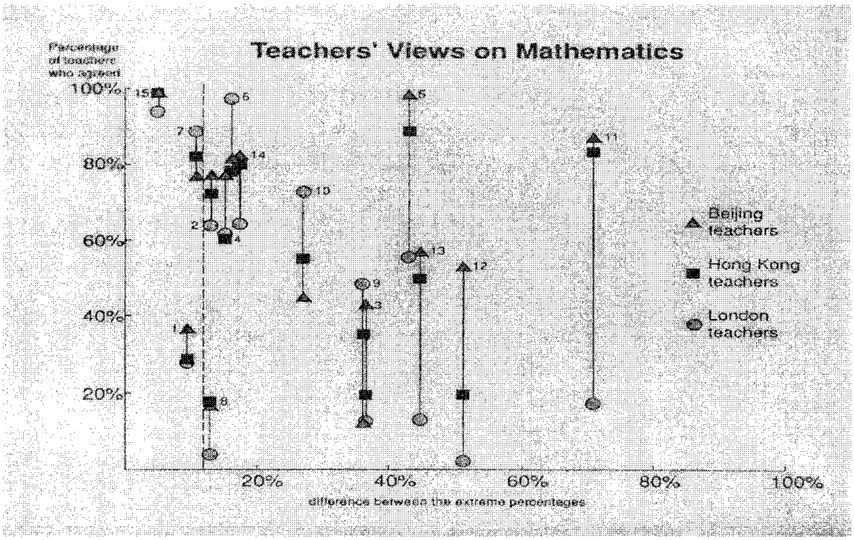

Figure -8. Views of Teachers from Beijing, Hong Kong and London on Mathematics

From Figure 8, we can see that teachers from the three cities differed tremendously in their attitudes towards mathematics. ANOVA tests showed that the responses of teachers from the three cities differed significantly in 12 of the 15 items on the scale. The item that attracted the greatest discrepancy of responses is item 11: "There is always a rule to follow in solving a mathematics problem". 87.6% and 83.1% of the teachers in Beijing and Hong

Kong respectively agreed with this statement (only 2.3% and 7.2% respectively disagreed) while only 17.0% of the London teachers agreed (64.7% of them disagreed). This statement perhaps best describes the difference in perception of mathematics among the teachers in the three cities. The Beijing teachers tended to view mathematics as a rule-oriented and fixed discipline, while teachers in London perceived mathematics as more heuristic and changing, and the attitudes of the Hong Kong teachers lay between these two extremes.

The more significant and interesting finding, however, is that a pattern of responses emerges across the three cities. All except three items follow a trend - with the response of the Hong Kong teachers lying between those of the Beijing and London teachers. (The three exceptional items, 4, 6 and 8, are near the middle of the list above, showing that they are items that attracted neither strong agreement nor strong disagreement among teachers in the three cities.) This pattern persists in the other items of the questionnaire, as we will see in later parts of this chapter.

6.1.2 Attitudes towards mathematics education

Three items in the questionnaire that measure teachers' attitudes towards mathematics teaching and learning will be discussed here.

(i) Aims of mathematics education

In one of the items in the questionnaire, teachers were asked what they thought the most important aims of mathematics education were for junior secondary school students, and their views are shown in Figure 9.

From Figure 9, we can see that teachers in all three cities did not think appreciating mathematics for its own worth an important aim in mathematics education. For the four other aims supplied in the question, teachers from different cities had different responses. Teachers in Beijing stressed mathematics as a tool for other subjects (52% thought this was the most important aim) and teachers in Hong Kong stressed the training of the mind (52%), while teachers in London stressed the ability to communicate logically and concisely (33%) and the applications of mathematics (39%).

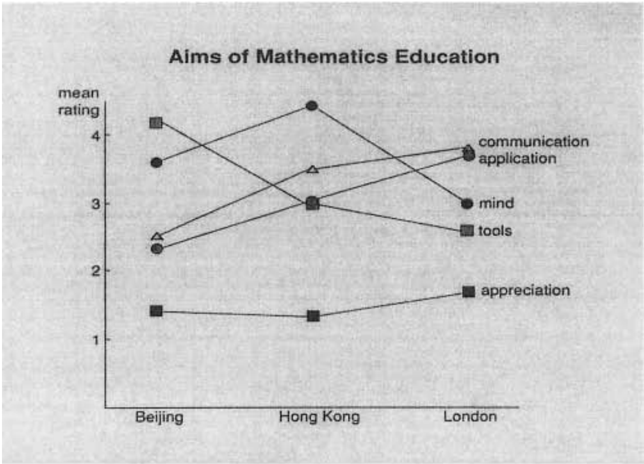

Figure -9. Teachers' Views on the Aims of Mathematics Education

(ii) Influences on mathematics content taught in the classroom

When teachers were asked what should have the greatest influence on the mathematics content taught in the classroom, some interesting contrasts between the views of teachers in the three cities emerged (see Figure 10).

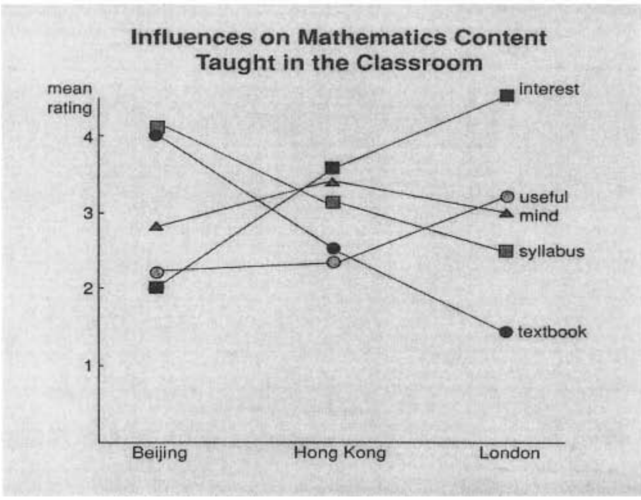

Figure -10. Teachers' Views on the Influence on Mathematics Content Taught

It can be seen from Figure 10 that in determining the mathematics content taught in the classroom, the views of the Beijing and London teachers were nearly diametrically opposed to each other. The most important consideration for the London (and Hong Kong) teachers seemed to be whether the content was interesting and meaningful for students, while for the Beijing teachers, interest did not seem to be a consideration at all.[6]

In Beijing, and to a lesser extent in Hong Kong as well, the syllabus seemed to dominate the content of mathematics taught in the classroom. The textbook was also thought to be an extremely important determinant of the content in Beijing, and in contrast, it was not an important consideration in the minds of the London teachers at all.

(iii) Factors affecting students' success and failure

When teachers were asked what they thought the most important factors affecting students' success or failure in mathematics were, teachers in all three cities did not consider luck or family support important factors (see Figure 11). But for the three other options, again an interesting pattern is obtained.

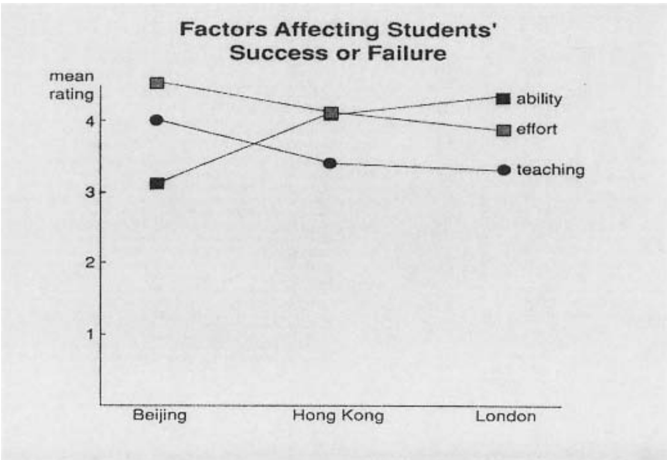

Figure -11. Teachers' Views on Factors Affecting Students' Success or failure

It seems from Figure 11 that teachers in Beijing believed in effort (put in by students and teachers) very much, and thought that the ability of students

[6] This view of the Beijing teachers may be accounted for by the traditional Chinese attitude towards studying and learning. For the Chinese, studying or learning is a serious endeavour and a hardship, and one is not supposed to "enjoy" the studying (Garvey and Jackson, 1975).

was not as important in determining success or failure in mathematics[7]. This contrasts sharply with the attitudes of the London teachers, who in general thought that the ability of students was the most important factor. The attitudes of the Hong Kong teachers again lay between those of their Beijing and London counterparts.

6.2 Confidence in preparation to teach mathematics

In TIMSS-R, an index of "teachers' confidence in preparation to teach mathematics" was developed from the teacher questionnaire to gauge teachers' confidence in teaching the different mathematics topics in the TIMSS curriculum framework. The results for some of the TIMSS-R countries are shown in Figure 12, and it can be seen that the East Asian teachers were in general not very confident in their preparedness to teach mathematics.

From the discussions above, we can see that the East Asian students are not taught by teachers who hold very positive attitudes towards mathematics and mathematics education, or are very confident in their teaching. It is hard to conclude from these findings that East Asian students' superior achievement is related to the attitudes of their teachers.

6.3 Reported teaching style

In past literature, it was reported that the teaching style in East Asia was rather traditional. Teaching was predominantly content oriented and examination driven. Instruction was very much teacher dominated, and student involvement was minimal. Teaching was usually conducted in whole class settings, with relatively large class size. There was virtually no group work or activities, and memorization of mathematics facts was stressed. Students were required to engage in ample practice of mathematical skills, mostly without thorough understanding (Brimer and Griffin, 1985; Biggs, 1996; Leung, 1995, 2001; Wong and Cheung, 1997; Wong, 1998).

In a comparative study of primary school mathematics teachers in China and the US by Ma (1999), teachers were interviewed on their approaches to teaching selected primary school mathematics topics. They were presented with some classroom scenarios and were asked how they would react to those scenarios. In an attempt to relate Ma's findings for the US and

[7] The Chinese conception of ability and effort is quite different from that in the West. The Chinese believe that ability is not "internal and uncontrollable" (Good and Weinstein, 1986), but something that one can "develop", as shown by the Chinese proverb "Diligence can compensate for stupidity".

Shanghai teachers to other East Asian teachers, a small-scale replication of Ma's study was carried out in Hong Kong and Korea (Leung and Park, 2002). Nine teachers from each of Hong Kong and Korea were interviewed using the four Teacher Education and Learning to Teach Study (TELT) (Ball, 1988) tasks that Ma used in her study, and some results of this replication study are reported below.

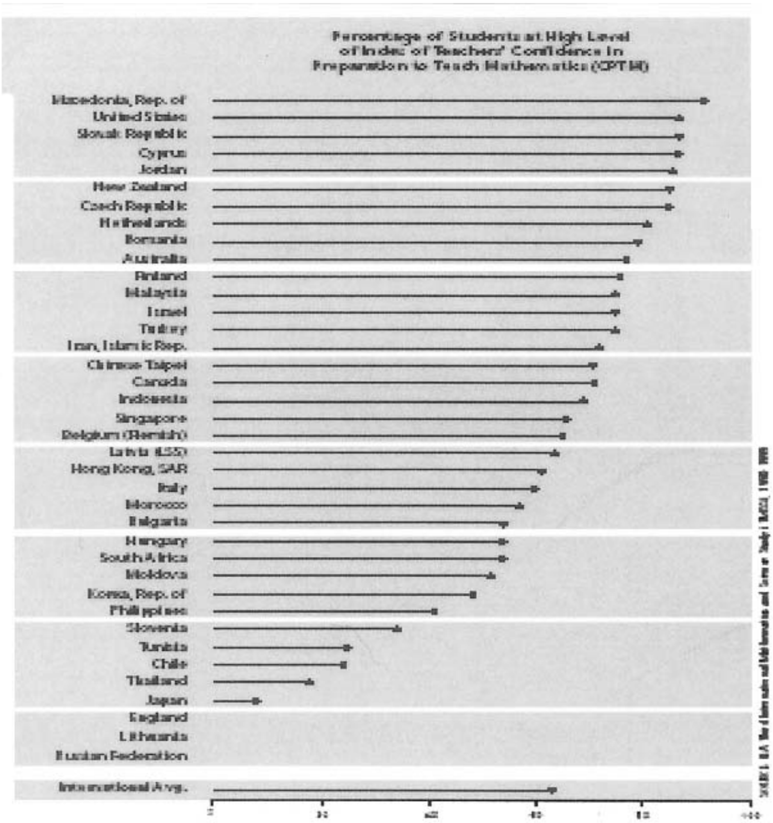

Figure -12. Index of Teachers' Confidence in Preparation to Teach Mathematics (adopted from TIMSS 1999 International Mathematics Report by Mullis et al, 2000)

Teachers' reaction to the following scenario reveals their teaching strategies in dealing with the topic of multi-digit number multiplication:

Task: Multi-digit Number Multiplication

Some sixth-grade teachers noticed that several of their students were making the same mistake in multiplying large numbers. In trying to calculate

```
  123
x 645
```

the students seemed to be forgetting to "move the numbers" (i.e., the partial products) over on each line. They were doing this:

```
   123
x  645
   615
   492
   738
  1845
```

instead of this:

```
  123
x 645
  615
 492
738
79335
```

While these teachers agreed that this was a problem, they did not agree on what to do about it. What would you do if you were teaching sixth grade and you noticed that several of your students were doing this?

In contrast to the Shanghai counterparts in Ma's study, the majority of the teaching strategies reported by Hong Kong and Korean teachers were procedurally rather than conceptually directed (see Table 3). The following excerpt of an interview with a Hong Kong teacher is a typical example of the reactions of the Hong Kong and Korean teachers in the replication study:

I: What would you do if you find your students are making this kind of mistake?

T: I'll teach them that if you use the hundreds place times the unit place, your answer should be written under the "6", align with this "6". Now the textbook leaves two empty spaces there, and I'll tell them if you have empty spaces, it is easy for you to align wrongly. So I'll teach them after you get the product, say six times three equals eighteen, you should immediately put down two zeroes in the two empty spaces. If you have something there, you won't align wrongly. So the first thing is to align, ... (It is) the same with the second number. It is the tens place, so you should put your answer under the tens place, and you put a zero at the unit place ...

How do the reported teaching strategies of Hong Kong and Korean teachers in the replication study compare with those of Shanghai and US teachers in Ma's study? Table 3 below combines the results of Ma's study and Leung and Park's replication study:

Table -3. Teaching Strategies

	US	Shanghai	Hong Kong	Korea
Procedurally directed	16 (70%)	9 (13%)	7 (78%)	6 (67%)
Conceptually directed	7 (30%)	63 (88%)	2 (22%)	3 (33%)

From Table 3, we can see that as far as reported teaching strategies are concerned, Hong Kong and Korean teachers were more akin to the US teachers rather than the Shanghai teachers in Ma's study.

6.4 Teachers' mathematics competence

Is the procedural teaching reported by the Hong Kong and Korean teachers in the replication study a reflection of their lack of competence in mathematics? In the interview, it was found that although the reported teaching style of East Asian teachers was rather traditional and procedural, these teachers actually possessed conceptual understanding of the procedures. In the multi-digit number multiplication discussed above, when teachers were probed further in the interview on the reasons for the procedures of "aligning" and "putting in zeroes", it was found that these teachers fully understood the rationale for "moving the numbers" (i.e. the partial products). Nearly all of them said that the students' problem was a lack of understanding of "place value", and they would break the multiplication into three partial multiplications to point out students' mistakes:

I: Why are students making this kind of mistake?

T: It's a problem with place value. In fact the 6 here stands for 600. I can change 645 into 600 + 40 + 5, and then do it step by step, dividing (the multiplication) into 123 x 600 + 123 x 40 + 123 x 5. Then I will address the problem of aligning the numbers (i.e. the partial products). I will tell them that you need to add in zeroes ...

So we can see that, unlike the US teachers in Ma's study, the East Asian teachers in the replication study possessed conceptual as well as procedural understanding of the algorithm behind multi-digit number multiplication (see Table 4), and it seems that they had the mathematics competence needed to teach the topic. However, as pointed out above, the majority of the teaching strategies reported by Hong Kong and Korean teachers were procedurally rather than conceptually directed (Table 3), despite their conceptual understanding of the mathematics involved.

Table -4. Teachers' Knowledge of Multi-digit Multiplication Algorithm

	US	Shanghai	Hong Kong	Korea
Procedural	14 (61%)	6 (8%)	0 (0%)	1 (11%)
Conceptual + procedural	9 (39%)	66 (92%)	9 (100%)	8 (89%)

Teachers' mathematics competence is also reflected in their response towards the following task in the study.

Task: Division by Fractions

People seem to have different approaches to solving problems involving division with fractions. How do you solve a problem like this one?

$$1\ 3/4 \div 1/2 =$$

Imagine that you are teaching division with fractions. To make this meaningful for kids, something that many teachers try to do is to relate mathematics to other things. Sometimes they try to come up with real-world situations or story-problems to show the application of some particular piece of content. What would you say would be a good story or model for

$$1\ 3/4 \div 1/2\ ?$$

All the teachers in Hong Kong, Korea and Shanghai were able to calculate the division correctly (see Table 5). Also, at least half of the teachers in each of these East Asian countries understood the division by fractions concept well enough to be able to generate a representation of the problem by providing a story.

Table -5. Teachers' Knowledge of Division by Fractions

	US	Shanghai	Hong Kong	Korea
Correct answer	9 (43%)	72 (100%)	9 (100%)	9 (100%)
Correct story	1 (4%)	65 (90%)	6 (67%)	5 (50%)

The results above show that most East Asian teachers were rather competent mathematically. They had a good grasp of the underlying concepts of school mathematics, and they were particularly proficient in the calculation procedures.

7. EXPLANATION AT THE LEVEL OF CULTURE

From the discussions in the preceding sections of this paper, we can see that other than the possible difference in competence of the teachers, none of the variables we reviewed at the levels of society, education system and teachers seemed to be able to explain the high achievement of East Asian students. However, a number of findings mentioned above prompt us to look at explanations at the level of culture. This will be further discussed below.

7.1 The low self-concept in mathematics

One of the striking findings of TIMSS-R discussed above is the negative attitudes towards mathematics and the lack of confidence in doing mathematics for students in the East Asian countries. One possible reason for this negative finding may be due to the stress in the cultures of these countries on the virtue of humility or modesty. As the author pointed out elsewhere (Leung, 2002: 106):

> Children from these countries are taught from when they are young that one should not be boastful. This may inhibit students from rating themselves too highly on the question of whether they think they do well in mathematics, and so the scores may represent less than what students are really thinking about themselves. On the other hand, one's confidence and self image are something that is reinforced by one's learned values, and if students are constantly taught to rate themselves low, they may internalize the idea to result in really low confidence. Furthermore, the competitive examinations systems coupled with the high expectations for student achievement in these countries have left a large number of students classified as failures in their system, and these repeated experiences of a sense of failure may have further reinforced this lack of confidence.

So this low self-concept in mathematics, and perhaps the negative attitude towards mathematics in general as well, may have a deeper cultural root. It may be something that students acquired while being brought up in the East Asian culture.

7.2 Teacher attitudes

The same argument may hold for the low confidence of teachers in preparation to teach mathematics mentioned earlier in this paper. But as far as teacher attitudes are concerned, the more important finding cited above is not that the negative attitudes of the East Asian teachers are due to the underlying cultural values, but that the attitudes of teachers from Beijing, Hong Kong and London, as reflected in their response to the questionnaire, followed a trend according to the cultural location of the place they come from. As was pointed out earlier in this paper, the attitudes of teachers in Beijing, Hong Kong and London nearly always form a pattern, with the attitudes of Hong Kong teachers falling between those of Beijing and London teachers.

The significance of this Beijing-Hong Kong-London pattern is attributable to the fact that Hong Kong was a British colony for more than one and a half centuries before reverting back to China in 1997. But because of her origin from and proximity with China, Hong Kong has never lost her cultural link with the motherland. On the contrary, being the most homogeneously ethnic Chinese community outside Mainland China and Taiwan, most of the Chinese traditions and values are still retained. Hong Kong's dramatic prosperity under British rule and the consequent development into one of the world's major communication and financial centres has however made it a city prone to influence by Western cultures. So culturally, Hong Kong may be considered to be located somewhere between China and England, and the findings discussed above do seem to confirm this influence of culture on teacher attitudes. This may be taken as an evidence of the effect of the cultural values on the attitudes of teachers (and students).

7.3 Teaching style

Another interesting finding discussed in this chapter is the predominantly procedural manner of teaching reported by Hong Kong and Korean teachers despite their good grasp of the underlying mathematical concepts. Is there a cultural explanation to this phenomenon?

The interview results of the replication study cited above show that Hong Kong and Korean teachers seemed to believe that, for elementary school, there is no need to teach in a conceptually rich manner. It would be inefficient or even confusing for elementary school children to be exposed to rich concepts instead of clear and simple procedures. The following view of a Korean teacher expressed during the interview illustrates this mentality well.

Teacher E:When I teach multiplication of three fractions in the sixth grade, I usually emphasize that multiplication should be done from left to right. For example, when I teach 4/7 ×5/3 ×1/2 , I always ask my students to multiply 4/7 ×5/3 first. The associative law holds for multiplication, so in fact there is no need to highlight this fact. You can say that I have taught a wrong method to students. However, I stress that fact because mentioning the order is helpful when students perform mixed operations with multiplication and division. Consider the operation 4/7 ÷5/3 ×1/2. Here, the order is important. If students do the multiplication first, they will get the wrong answer. I ask students to follow the rule of order, which is not strictly correct mathematically, because I consider the operation which will be dealt with in the next chapter.

From the excerpt above we can see that this Korean teacher understood the mathematics concepts behind the multiplication of fractions, but she deliberately taught students a rule which is "not strictly correct mathematically" in order not to confuse the students. This stress on the procedure instead of concepts for the sake of efficiency illustrates very well the pragmatic philosophy in the East Asian culture. Such a pragmatic mentality compels East Asian teachers to deliberately teach in a procedural manner for pedagogical reasons.

7.4 Why do East Asian students excel?

Given that East Asian students possess such negative attitudes towards mathematics and hold such low self-concept in mathematics, and are taught by teachers using teaching methods that stress procedures rather than concepts, why do the East Asian students perform so well in international studies of mathematics achievement?

Paradoxically, one may argue that this negative correlation between students' confidence in mathematics and their achievement is something to be expected:

> Over-confidence may lower students' incentive to learn further and cause them to put very little effort into their studying, and hence result in low achievement. This is exactly the kind of justification for the stress on humility or modesty in the East Asian culture. The Chinese saying "contentedness leads to loss, humility leads to gain" illustrates the point well.
>
> (Leung, 2002:16)

Also, it should be noted that procedural teaching does not necessarily imply rote learning or learning without understanding. Understanding is "not a yes or no matter, but a continuous process or a continuum" (Leung, 2001). The process of learning often starts with gaining competence in the procedure, and then through repeated practice, students gain understanding. Much of the mathematics in the school curriculum may need to be practiced without thorough understanding first. With a set of practicing exercises that vary systematically, repeated practice may become an important "route to understanding" (Hess and Azuma, 1991). As Marton pointed out (1997), in the East Asian culture, repetitive learning is "continuous practice with increasing variation". This is perhaps the way both teachers and students in East Asia acquire their mathematics competence.

7.5 The competence cycle

In the replication study cited above, Hong Kong and Korean teachers were asked when and where they acquired their mathematics competence. They indicated that their mathematics and pedagogical competence were mainly acquired while they were still students in school. So it seems that mathematics competence is "inherited". East Asian students, taught by their competent teachers, acquire competence in mathematics. When they graduate and join the teacher force, they in turn become competent teachers. Once a good cycle starts, the positive effects cumulate and increasingly reproduce themselves. Unfortunately, this holds true for a vicious cycle as well.

But how did the good cycle start in the first place? One possible root for the start of the good cycle is the underlying Confucian cultural values common to the East Asian countries. It is well known that in the Confucian culture, there is strong emphasis on the importance of education. Under the influence of this philosophy, East Asians consider learning or studying a serious endeavour, and students are expected to put in hard work and perseverance in their study. This is reinforced by a long and strong tradition of public examination, which acts as a further source of motivation for learning. This high expectation on the student to achieve provides an important source of motivation both for teachers to teach conscientiously and for students to learn well.

Related to this strong emphasis on the importance of education, there is a tacit expectation and strong tradition in the East Asian culture that the teacher should be an expert or a learned figure in the subject matter. This expectation provides incentives for East Asian teachers to strive to attain competence in mathematics. Probably it is this prevailing cultural value of the emphasis on education and the scholar-teacher that starts and keeps the good cycle of competent teachers-competent students in East Asia.

8. CONCLUSION

This paper is prompted by the superior performance of East Asian students over their Western counterparts in international studies of mathematics achievement, and it seeks to explore whether differences in other aspects of education or the system may be used to explain the differences in achievement. A number of factors at the levels of societal resources, the education system, and the teachers, thought to be related to student achievement, were examined. The findings indicate that despite a more or less common legacy of Greek mathematics and the recent globalization in education, mathematics education in East Asia and the West retains important differences. There are differences in terms of student achievement, student attitudes, teacher attitudes, teaching style, and teacher competence. The various institutional and societal variables examined fail to explain these differences, and possibly it is factors beyond those falling in these levels that are at work in having an effect on student achievement.

Since these high achieving countries share a common culture, roughly referred to as the Chinese or Confucian culture, a number of characteristics of the culture were examined to see whether they may be used to explain the differences in student achievement and other variables in mathematics education. As the discussion in this chapter shows, there are indeed different cultural values pertinent to education that may explain the differences. This is of course no proof that differences in student achievement are caused by cultural differences. But in the absence of clues from variables at other levels, it is probable that culture does matters.

If culture does matter, what are the implications of the cultural differences for mathematics education in both East Asian countries and those from the West? These are issues that will be discussed in the rest of the chapters in this book.

REFERENCES

Ball, D., 1988, *Knowledge and Reasoning in Mathematical Pedagogy: Examining What Prospective Teachers Bring to Teacher Education*", unpublished doctoral dissertation, Michigan State University, East Lansing.

Biggs, J.B. 1996, Western Misconceptions of the Confucian-Heritage Learning Culture, in: *The Chinese Learner: Cultural, Psychological and Contextual Influences*, Watkins D.A. and Biggs, J.B, eds., Comparative Education Research Centre, Hong Kong, pp.45-68.

Beaton, A.E., Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., Kelly, D.L. and Smith, T.A., 1996, *Mathematics Achievement in the Middle School Years*, Centre for the Study of Testing, Evaluation and Educational Policy, Boston College, Boston.

Brimer,A. and Griffin,P., 1985, *Mathematics Achievement in Hong Kong Secondary Schools*, Centre of Asian Studies, University of Hong Kong, Hong Kong.

Dahlin, B. and Watkins, D., 2000, The Role of Repetition in the Process of Memorisation and Understanding: A Comparison of Views of German and Chinese Secondary School Students in Hong Kong, *British Journal of Educational Psychology*, **70**:65-84.

Garvey, A. and Jackson, B., 1975, *Chinese Children. Research and Action Project into the Needs of Chinese Children*, National Education Research Development Trust, Cambridge.

Good, T. and Weinstein, R., 1986, Teacher Expectations, in: *Improving Teaching: 1986 ASCD Yearbook*, Zumwalt, K., ed., Association for Supervision and Curriculum Development, Alexandria, VA.

Hammouri, H.A.M, 2004, Attitudinal and Motivational Variables Related to Mathematics Achievement in Jordan: Findings from the Third International Mathematics and Science Study (TIMSS), *Educational Research*, **46**(3):241-257.

Hess, R.D. and Azuma, M., 1991, Cultural Support for Schooling: Contrasts between Japan and the United States, *Education Researcher*, **20**(9):2-8.

Howson, G. and Wilson, B., 1986, *School Mathematics in the 1990s*, Cambridge University Press, Cambridge.

Lapointe, A.E., Mead, N.A., and Askwe, J.M., 1992, *The International Assessment of Educational Progress Report No. 22-CAEP-01: Learning Mathematics*, The Centre for the Assessment of Educational Progress, Educational Testing Service, New Jersey.

Leung, F.K.S., 1992, *A Comparison of the Intended Mathematics Curriculum in China, Hong Kong and England and the Implementation in Beijing, Hong Kong and London*, Ph.D. thesis, the University of London.

Leung, F.K.S., 1995, The Mathematics Classroom in Beijing, Hong Kong and London, *Educational Studies in Mathematics*, **29**:197-325.

Leung, F.K.S., 2001, In Search of an East Asian Identity in Mathematics Education, *Educational Studies in Mathematics*, **47**:35-51.

Leung, F.K.S., 2002, Behind the High Achievement of East Asian Students, *Educational Research and Evaluation*, **8**(1):87-108.

Leung, F.K.S. and Park, K.M., 2002, Competent Students, Competent Teachers?, *International Journal of Educational Research*, **37**(2):113-129.

Ma, L., 1999, *Knowing and Teaching Elementary Mathematics*, Lawrence Erlbaum Associates, Publishers, Mahwah, N.J.

Ma, X. and Kishor, N., 1997, Assessing the Relationship between Attitude towards Mathematics and Achievement in Mathematics: A Meta-Analysis, *Journal for Research in Mathematics Education*, **28**(1):26-47.

Marton, F., 1997, Student Learning: East and West, public lecture delivered at the Chinese University of Hong Kong, March 18.

McLeod, D.B., 1992, Research on Affect in Mathematics Education: A Reconceptualisation, in: *Handbook of Research on Mathematics Teaching and Learning*, D.A. Grouws, ed., MacMillan, New York, pp. 575-596.

Muijs, R.D., 1997, Predictors of Academic Achievement and Academic Self-Concept: A Longitudinal Perspective, *British Journal of Educational Psychology*, **67**:263-277.

Mullis, I.V.S., Martin, M.O., Beaton, A.E., Gonzalez, E.J., Kelly, D.L. and Smith, T.A., 1997, *Mathematics Achievement in the Primary School Years*. Centre for the Study of Testing, Evaluation and Educational Policy, Boston College, Boston.

Mullis, I.V.S., Martin, M.O, Gonzalez, E.J., Gregory, K.D., Garden, R.A., O'Connor, K.M., Chrostowski, S.J. and Smith, T.A., 2000, *TIMSS 1999 International Mathematics Report*, International Study Center, Lynch School of Education, Boston College, Boston.

Organisation for Economic Co-operation and Development, 2001, *Knowledge and Skills for Life: First Results from PISA 2000*, OECD Publications, Paris.

Organisation for Economic Co-operation and Development, 2003, *Literacy Skills for the World of Tomorrow - Further Results from PISA 2000*, OECD Publications, Paris.

Robitaille, D.F. and Garden, R.A. ed., 1989, *The IEA Study of Mathematics II: Contexts and Outcomes of School Mathematics*, Pergamon Press, Oxford.

Stevenson, H.W., Lummis,M., Lee,S. and Stigler,J., 1990, *Making the Grade in Mathematics: Chinese, Japanese and American Children*, National Council of Teachers of Mathematics, Reston, VA.

Stevenson, H.W., Chen, C. and Lee, S.Y., 1993, Mathematics Achievement of Chinese, Japanese, and American Children: Ten Years Later, *Science*, **25**(9):53-58.

Stigler, J.W. and Hiebert, J., 1999, *The Teaching Gap*. Free Press, New York.

Wong, N.Y., 1998, In Search of the 'CHC' Learner: Smarter, Works Harder or Something More? Plenary lecture, in: *Proceedings of the ICMI-East Asia Regional Conference on Mathematical Education*, H.S. Park, Y.H. Choe, H. Shin, and S.H. Kim, eds., **1**:85-98.

Wong, K.M. and Cheung, W.W., 1997, A Survey of the Current State of Primary Mathematics Teaching in Hong Kong, *EduMath*, **4**:3-15.