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SOME CHARACTERISTICS OF EAST ASIAN MATHEMATICS CLASSROOMS BASED ON DATA FROM THE TIMSS 1999 VIDEO STUDY

ABSTRACT. In this paper, characteristics of mathematics classrooms in the East Asian countries[1] of Hong Kong and Japan are discussed based on an analysis of the data of the TIMSS 1999 Video Study. The data shows that although students in these East Asian countries did not talk a lot in the classroom, they were exposed to more instructional content. The mathematics problems they worked on were set up mainly using mathematical language, and compared with the problems solved by students in other countries, the problems took a longer duration to solve and more proof was involved. According to the judgement of an expert panel on the Hong Kong lessons (Japan did not participate in this part of the study), more advanced contents were covered and the lessons were more coherent. The mathematics presentations were more developed, and the students were more likely to be engaged in the lessons. In sum, the overall quality of the teaching in this East Asian country was judged to be high. The findings show that high quality teaching and learning can take place even in a teacher directed classroom. It is argued that these East Asian classroom practices are deeply rooted in the underlying cultural values of the classroom and the wider society. The paper ends by drawing some implications of the study for the mathematics education community in other cultures.

KEY WORDS: advanced mathematics content, culture, East Asia, mathematical language, quality of teaching, teacher directed classroom, teacher talk, video study

1. INTRODUCTION

The superior performance of students from East Asian countries[1] in international comparative studies of mathematics achievement (Beaton et al., 1996; Lapointe et al., 1992; Mullis et al., 1997, 2000; Organisation for Economic Co-operation and Development, 2001, 2003; Robitaille and Garden, 1989; Stevenson et al., 1990, 1993; Stevenson and Lee, 1997) has prompted considerable speculation on factors that might account for it (Ho, 1986; Leung, 2001; Leung and Park, 2002; Ma, 1999; Park and Leung, 2003; Stevenson, 1987). Since students acquire most of their mathematics knowledge in the classroom, it is reasonable to expect that the instruction they receive should be a major factor influencing achievement. In consequence, there have been a number of large scale video studies to examine instructional practices in mathematics classrooms in various countries (e.g., Clarke, 2002).

Educational Studies in Mathematics (2005) 60: 199–215
DOI: 10.1007/s10649-005-3835-8

For example, in parallel with the Third International Mathematics and Science Study (TIMSS 1995), a video study of instructional practices in eighth-grade mathematics was conducted for the three countries of Germany, Japan and the United States. The study showed that classroom teaching in Japan is substantially different from that in Germany and the United States (Stigler and Hiebert, 1999). A similar but larger scale study was conducted alongside TIMSS 1999. In the TIMSS 1999 Video Study of seven countries (Australia, Czech Republic, Hong Kong SAR, Japan,[2] the Netherlands, Switzerland, the United States), the main goal was to describe and compare eighth-grade mathematics teaching for to the following reasons.

- Develop objective, observational measures of classroom instruction to serve as appropriate quantitative indicators of teaching practices in each country.
- Compare teaching practices among countries and identify similar or different lesson features across countries.
- Describe patterns of teaching practices within each country.
- Develop methods for communicating the results of the study, through written reports and video cases, for both research and professional development purposes.

(Hiebert et al., 2003, pp. 1–2)

The report of the study was released in March 2003 (Hiebert et al., 2003). Since the East Asian countries of Hong Kong and Japan participated in the study, it provides data for this study of the characteristics of teaching in East Asian mathematics classrooms.

1.1. *Brief description of the TIMSS 1999 video study*

The TIMSS 1999 Video Study utilized a national probability sample[3] of a target of 100 eighth-grade lessons per country, and the findings can be taken as representative of the teaching in the countries concerned. Because of the high cost involved in videotaping, only one lesson per teacher was videotaped. Consequently, interpretation of data should be limited to national-level descriptions and comparisons of individual lessons, not the full range of teaching practices and dynamics that might appear in units that stretch over days and weeks (Hiebert et al., 2003, p. 7). The purpose of the study is to get an overall impression of the mathematics teaching in a certain country, rather than to evaluate the performance of individual teachers. Since different countries cover different content in their eighth grade, it has not been possible to choose a common topic for videotaping. Instead, lessons were sampled across the school year to ensure a comprehensive coverage

of the content taught in the eighth grade in each of the countries. Videotaping followed standardized camera procedures, with one camera focusing on the teacher and another camera focusing on the class as a whole. Altogether 638 mathematics lessons were videotaped, ranging from 50 lessons in Japan to 140 lessons in Switzerland (the mean number of videotaped lessons per country is 92).

An international team of coders from the participating countries developed a set of 45 codes and applied them to the video data, as described in the project report (Hiebert et al., 2003). In addition, a number of more qualitative analyses were performed, including that by an expert panel, known as the Mathematics Quality Analysis Group, comprising mathematicians and mathematics educators at the post-secondary level. The group reviewed a randomly selected subset of 120 lessons (20 lessons from each country except Japan[4]) based on detailed written descriptions of the lessons prepared by the international video coding team. These lesson descriptions were examined "country-blind", with all indicators that might reveal the country removed.

2. FINDINGS

The results of the analysis of the TIMSS 1999 Video Study data for the purpose of this paper will be presented in two parts. First, from the results of the quantitative analysis of the coded data, distinctive features of the classrooms in the two East Asian countries in the study, namely, Hong Kong and Japan, will be identified. Then, relevant results of the analysis from the Mathematics Quality Analysis Group will be reported to supplement the picture obtained from the quantitative analysis of the codes.

2.1. *Quantitative analysis of the coded data*

2.1.1. *Dominance of teacher talk*

The stereotype of the East Asian classroom is one dominated by teacher talk. However, the results of this study show that the dominance of teacher talk is not exclusive to East Asian classrooms. In all of the countries studied, the teacher did a lot of talking, and considerably more than their students (Figure 1).

Interestingly, the two East Asian countries differ considerably in the amount of teacher talk. Hong Kong teachers were among the most talkative teachers in the participating countries (second only to the US teachers), while the Japanese teachers spoke the least number of words. Figure 1 shows that on average Hong Kong teachers spoke nearly 5800 words per

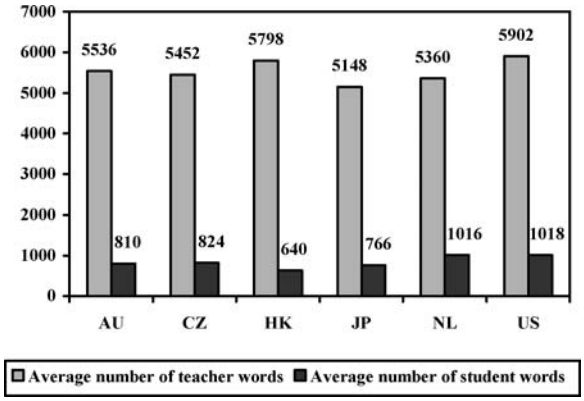

Figure 1. Average number of teacher and student words per lesson.

lesson[5], while Japanese teachers spoke only 5148 words per lesson, compared with the average of 5533 words across all the countries. On the other hand, students in Hong Kong and Japan were the least talkative in the study: 640 words per lesson in Hong Kong and 766 words in Japan, compared with an average of 845 words across all countries.

The picture of the East Asian classroom becomes clearer when we look at the ratio of the average number of words spoken by students to those spoken by their teachers during the lesson (Figure 2). It can be seen from Figure 2 that the verbal dominance of the East Asian teachers is very evident. For every word that a student uttered, the Hong Kong teacher spoke an average of 16 words and the Japanese teacher spoke an average of 13 words, compared to the minimum ratio of 1:8 (US), and an average

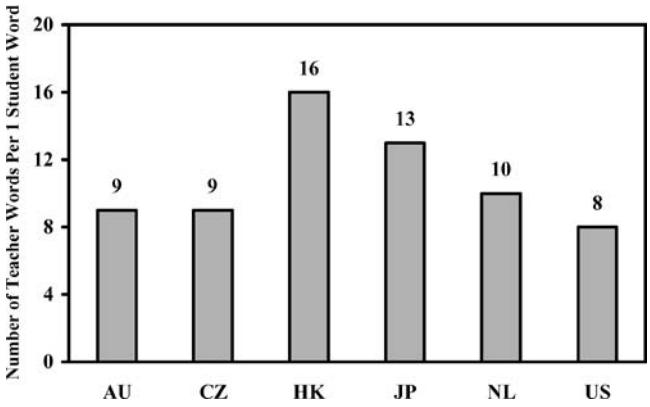

Figure 2. Average number of teacher words to every one student word per lesson.

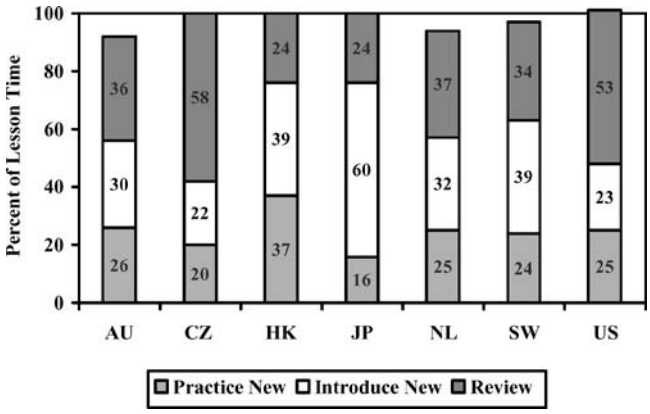

Figure 3. Average percentage of lesson time devoted to various purposes.

of 1:11. When we factor in the relatively large class size of the East Asian classroom,[6] the reticence of the East Asian students is even more striking.

2.1.2. *More opportunities to learn new content*

The TIMSS 1999 Video Study classified the purposes of lesson segments according to whether they are for *reviewing* (addressing content introduced in previous lessons), *introducing new content* (content that students have not worked on in earlier lessons), or *practicing new content* (students practicing or applying content introduced in the current lesson). The average percentages of lesson time devoted to each of the three purposes are shown in Figure 3.

It can be seen from Figure 3 that more than 75% of lesson time in the East Asian classroom is spent dealing with new content (either introducing new content or practicing new content). This is substantially more than the time allocated to this same purpose in other countries (between 42% (Czech Republic) and 63% (Switzerland)). One tentative inference from this data is that East Asian students learn more subject matter than their counterparts in other countries.

2.1.3. *Problems more complex*

It was found that lesson time in all seven countries was dominated by students working with mathematical problems, an important aspect of which is their procedural complexity. Procedural complexity is defined in the TIMSS 1999 Video Study as "the number of steps it takes to solve a problem using a common solution method" (Hiebert et al., 2003, p. 70), and Figure 4 shows the average percentage of problems at different levels of procedural complexity. It can be seen from Figure 4 that the problems

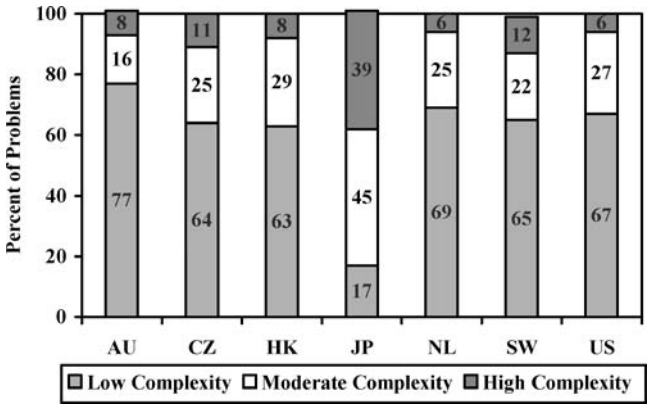

Figure 4. Average percentage of problems per lesson at each level of procedural complexity.

Japanese students worked on were procedurally much more complex than those worked on in other countries. The problems Hong Kong students worked on did not seem to be particularly more complex procedurally than those worked on in other countries, although the percentage of low complexity problems (63%) in Hong Kong was marginally smaller than those in other countries (except Japan).

Another measure of problem complexity is the length of time students spend working on it, and Figure 5 shows the average percentage of problems that were worked on for more than 45 seconds. From the two Figures, we can see that in general, East Asian students have more opportunities to work on procedurally more complex problems which required a longer duration to solve.

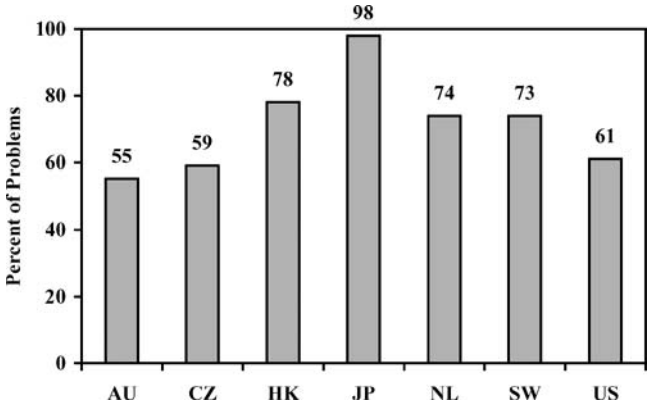

Figure 5. Average percentage of problems per lesson that were worked on for longer than 45 s.

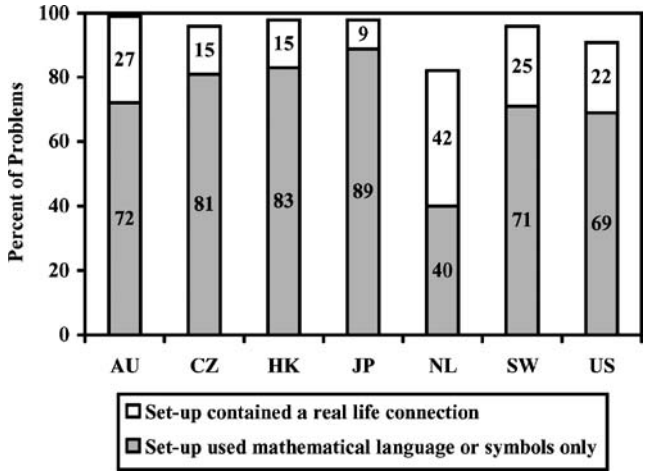

Figure 6. Average percentage of problems per lesson set up with a real life connection or with mathematical language or symbols only.

2.1.4. *Problems set up using mathematical language*

Different mathematics educators may hold different views on whether mathematics problems should be presented within real-life contexts or whether they should be expressed only in mathematical language and symbols (Lesh and Lamon, 1992; Prawat, 1991; Streefland, 1991), and their views may reflect their different philosophical positions on the nature of mathematics and mathematics learning (Park and Leung, 2002). Another characteristic of the problems deployed by teachers in the two East Asian countries is that the majority were expressed in mathematical language and symbols, and set in contexts unrelated to the real life. In this regard, East Asian classrooms are similar to those in the Czech Republic, but differ markedly from those in the Netherlands (Figure 6).

2.1.5. *More proof*

Proof has always been considered a distinctive feature of mathematics, although the role of proof in school mathematics has been a matter of debate for many years (see for example Hanna, 1997). Hence it will be of interest to identify how much proof is present in the problems worked on by students in different countries. Figure 7 shows that the problems on which East Asian students worked involved more proof than those worked on by students in other countries. The emphasis on proof is particularly marked in Japan, with Hong Kong being more in line with practice in Switzerland.

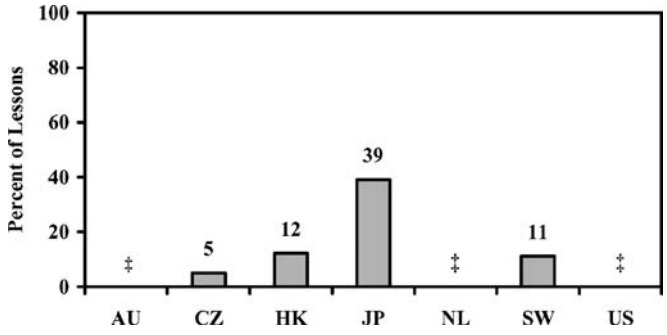

Figure 7. Percentage of lessons that contained at least one proof.

2.2. *Analysis by the mathematics quality analysis group*

As described earlier, an expert panel reviewed detailed descriptions of a random subset of the videotaped lessons country-blind in order to make qualitative judgements about them. In addition to judging the content level of the lesson, the panel assessed the quality of the mathematics in the lessons along the four dimensions of *coherence, presentation, engagement* and *overall quality*.[7]

2.2.1. *More advanced content*

The panel reviewed the mathematical content of the lessons in the sub-sample and classified each of the lessons into one of five curricular levels, from elementary to advanced. As indicated in Figure 8, the panel found the content covered in the Hong Kong[8] (and Czech Republic) lessons relatively more advanced than that in other countries.

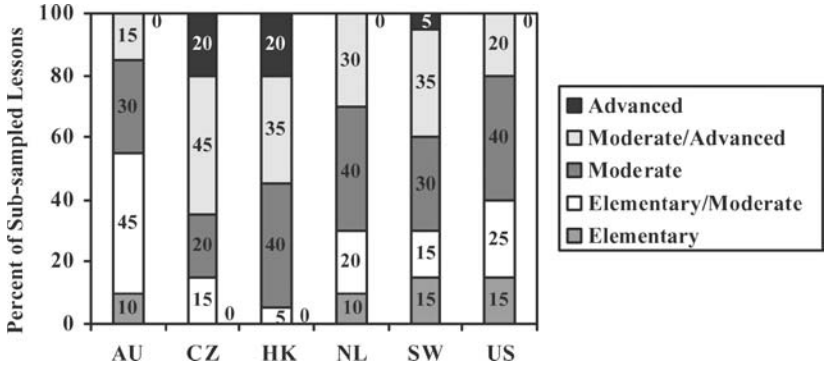

Figure 8. Percentage of lessons in sub-sample at each content level.

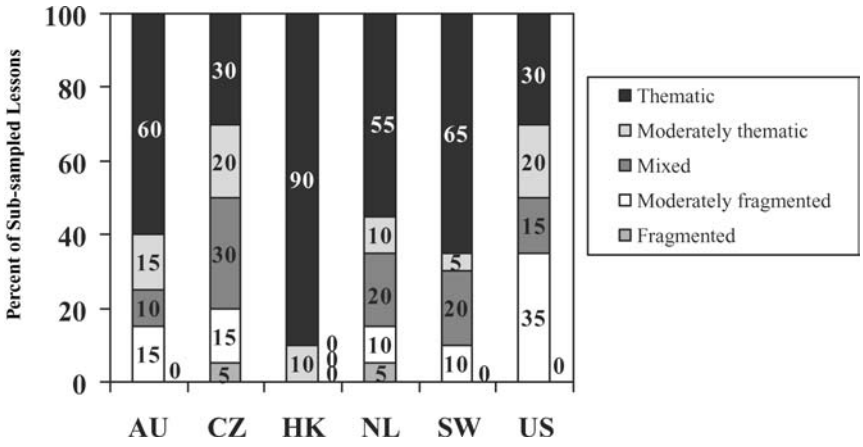

Figure 9. Percentage of lessons in sub-sample rated at each level of coherence.

2.2.2. *Lesson more coherent*

Coherence was defined by the panel as "the (implicit and explicit) interrelation of all mathematical components of the lesson" (Hiebert et al., 2003, p. 196). As can be seen from Figure 9, 90% of the Hong Kong lessons are judged to be thematically coherent, with the remaining 10% moderately thematically coherent – striking contrast with the Czech Republic and the United States, where only 30% was judged to be thematically coherent.

2.2.3. *More fully developed presentation*

Not only were the Hong Kong lessons judged to be more coherent, their presentation was found to be more fully developed. Presentation was defined by the panel as "the extent to which the lesson included some development of the mathematical concepts or procedures" (Hiebert et al., 2003, p. 197). Development required that mathematical reasons or justifications were given for the mathematical results presented or used. Presentation ratings took into account the quality of mathematical arguments: higher ratings meant that sound mathematical reasons were provided by the teacher (or students) for concepts and procedures. Mathematical errors made by the teacher reduced the ratings. The results of the judgement of the panel are shown in Figure 10. It can be seen that three quarters of the lessons in Hong Kong were classified as either 'fully developed' or 'substantially developed' – a figure three times higher than that for mathematics lessons in the Netherlands.

2.2.4. *Students more likely to be engaged*

As noted previously, the panel did not watch the videotapes (since the exercise was conducted "country-blind") and so could not easily judge whether

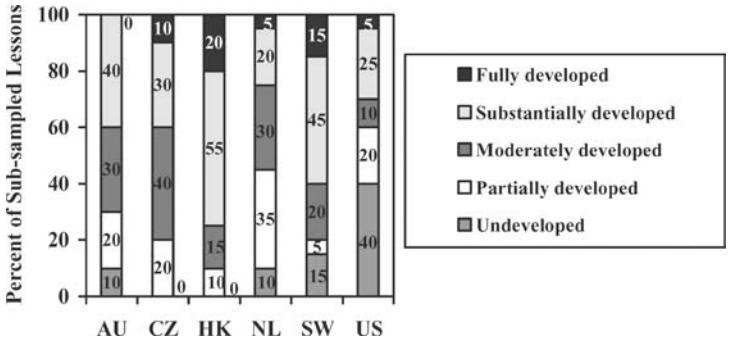

Figure 10. Percentage of lessons in sub-sample rated at each level of presentation.

students were engaged in the lessons or not. From the detailed descriptions of the lessons compiled by the international coding team, the panel made a judgement as to how likely it was that students would be engaged in the lesson. Student engagement was defined by the panel as "the likelihood that students would be actively engaged in meaningful mathematics during the lesson" (Hiebert et al., 2003, p. 198). A rating of 'very unlikely' (1) indicated a lesson in which students were asked to work on few of the problems in the lesson and those problems did not appear to stimulate reflection on mathematical concepts or procedures; a rating of 'very likely' (5) indicated a lesson in which students were expected to work actively on, and make progress solving, problems that appeared to raise interesting mathematical questions for them and then to discuss their solutions with the class. As can be seen from Figure 11, the panel inferred that students in Hong Kong classrooms were more likely than those elsewhere to be engaged in the lesson.

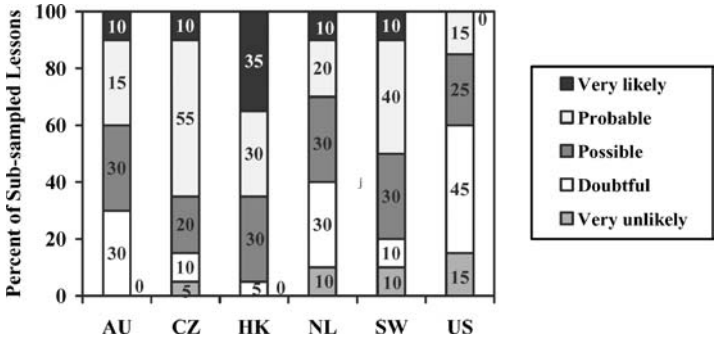

Figure 11. Percentage of lessons in sub-sample rated at each level of student engagement.

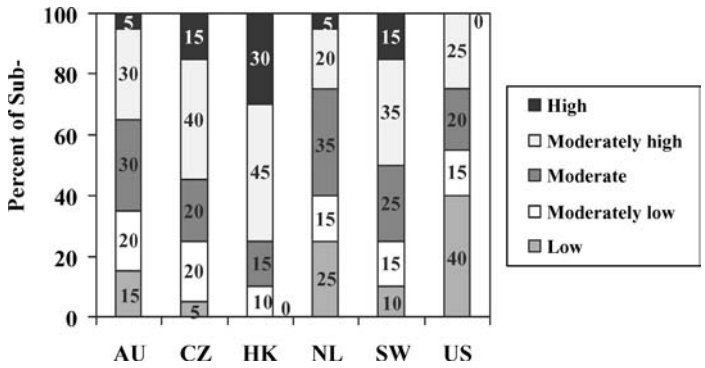

Figure 12. Percentage of lessons in sub-sample rated at each level of overall quality.

2.2.5. *Overall quality*

Finally, the panel made a judgement on the overall quality of the lessons in terms of "the opportunities that the lesson provided for students to construct important mathematical understandings" (Hiebert et al., 2003, p. 199). Figure 12 indicates that 30% of the Hong Kong lessons were judged to be of high quality, whereas only 5% of the lessons in Australia and the Netherlands were judged to be so. And in the US, none of the lessons were judged to be of high quality. There were also more lessons in Hong Kong than in other countries for which the panel judged the overall quality to be 'high' or 'moderately high'.

3. DISCUSSION

Some of the findings of the TIMSS 1999 Video Study seem to confirm the stereotype of the East Asian classroom, while some findings may shed new light in explaining the high mathematics achievement of East Asian students. The fact that East Asian countries have relatively large class sizes is well known, and the dominance of teacher talk and the reticence of students are consistent with the stereotype many people have of the East Asian classroom. However, the data shows that high quality teaching and learning can take place even in such large classes, suggesting that the nature of the activities taking place in the classroom is more important than the size of the class. Despite the rhetoric of constructivism and student-centred learning to the contrary, the findings of this study show that meaningful learning can still take place in a teacher directed classroom. Teacher dominance with a lot of teacher talk does not necessarily lead to passive, receptive learning. Much depends on the content of the teacher talk and how it is

delivered, and whether the talk can stimulate students to be engaged in the mathematics. Indeed, from the data obtained in this study, it seems that the kind of teacher talk in the East Asian classroom was able to direct students to be engaged in the lesson.

A striking characteristic of the East Asian classroom is the kind of content that is covered. Not only did East Asian students learn more new content than their counterparts in the West, but the content they learned was considered more complex and advanced – a finding which suggests that teachers in East Asia are sufficiently competent in mathematics to deliver complex and advanced content (see below).

Part of the reason for the content being considered more advanced resides in the more frequent occurrence of proof and the more prevalent use of mathematical language. In many countries, mathematical language is considered too alien and proof is considered too abstract for school students. Both are deemed to be too difficult for school students and are thus excluded from the curricula. However, both have traditionally been regarded as distinctive features of mathematics, and it seems that they are still judged to be so in the East Asian classroom. It seems highly likely that there is a close relationship between emphasis on this abstract aspect of mathematics in the East Asian classroom and the superior performance of students in international comparative studies of mathematics achievement. It should be pointed out that neither rigorous mathematical language nor proof was specifically stressed in international studies such as TIMSS and PISA. So, could it be that a firm foundation in mathematics is being laid for East Asian students through the heavy emphasis on mathematical language and proof and that this style of teaching enables these students to do well in the less abstract tasks in the international tests? In a milieu which seems to believe that the most effective way to enhance understanding and raise attainment levels is through an improved pedagogy, the clear indication that the high achievement of East Asian students is related to the high quality of the mathematics content to which they are exposed, should act as a sharp reminder that without quality content, quality learning will not take place – no matter how ingenious the teaching method.

The findings of this study also show that the more complex and advanced content of the East Asian classroom was more coherently presented to the students, and the mathematical concepts were more fully developed in the presentation. It is therefore not surprising that the students are judged to be more engaged in the learning, and the overall quality of the lessons was judged to be high, by the Mathematics Quality Analysis Group. This finding is further evidence that quality teaching is possible even with a large class and with the teacher dominating the teaching. The fact that the East Asian lessons are more coherent and better developed in terms of presentation

may be attributed to the mathematics competence of the teachers. It may also be attributed to the pedagogical competence of the teachers. Indeed, as Ma (1999) pointed out, competence in mathematics and pedagogy are intrinsically related: without a profound understanding of mathematics, it is not possible to invoke the appropriate pedagogy.

That more advanced content was covered in the East Asian classroom than in Western classrooms suggests that teachers in East Asia have higher expectations of their students in terms of the kind of mathematics they can learn. This conclusion is consistent with published literature on the consistently high expectation levels placed on East Asian students in mathematics (Hess et al., 1987; Stevenson, 1987). In contrast, the level of expected mathematics achievement in many Western countries seems to be declining. Mathematics is considered by students and teachers alike as a difficult subject, and the majority of the student population is not expected to learn the more advanced elements of mathematics, and are not even expected to do well in the elementary parts of the subject. The low achievement of students thus becomes a kind of self-fulfilling prophecy.

That more proof was involved and more mathematical language was utilized in the East Asian classroom may reflect East Asian teachers' conception of the nature of mathematics. It seems that East Asian teachers endorse the traditional view of mathematics as essentially an abstract structure that needs to be taught as such. East Asian teachers seem to put more emphasis on the objective and established nature of mathematics than the subjective and private realm of mathematics knowledge (Ernest, 1991). On the other hand, many Western mathematics educators regard mathematics in essence as the process of dealing with certain aspects of reality. In consequence, the process of 'doing mathematics' that the individual regards as appropriate is seen as more important than learning the established structure of mathematics. Thus, the East Asian view would be considered out-dated and not conducive to developing student learning. Clearly, international studies of mathematics achievement combined with the findings of this study suggest that this supposedly outmoded view of mathematics is able to produce students who excel.

The observation that the East Asian classroom is teacher-dominated, with a lot of teacher talk, seems to be at odds with the kind of teaching advocated by those who subscribe to a constructivist approach. However, a well-structured teacher-led lesson, as many of the East Asian lessons in this study seem to be, will assist students in constructing their mathematics knowledge. Indeed, a well-taught teacher-dominated lesson may better provide the mathematical coherence which students need in their construction of mathematical knowledge rather more effectively than many student-led approaches.

The high quality teaching found in this study suggests that East Asian teachers are more competent than their Western counterparts, not only in the subject matter of mathematics itself, but also in selecting an appropriate pedagogy, and that this may be an important factor contributing to East Asian students' high achievement in mathematics. Indeed, other studies have shown that East Asian teachers are relatively more competent in the subject matter than their Western counterparts (Ma, 1999; Leung and Park, 2002). It is interesting to speculate on whether this greater competence is related to the ideal of the "scholar teacher" in East Asian culture. In traditional Chinese culture, referred to by some scholars (Biggs, 1996) as the "Confucian Heritage Culture", the image of the teacher is that of an expert or a learned figure in the subject matter. Of course, skills in teaching are also important, but teachers will not be respected if they are not expert in the area they teach. This image of the scholar-teacher may provide incentives for East Asian teachers to strive to attain high levels of competence in the subject matter as well as in pedagogy. Indeed, it could be argued that cultural factors, which "touch upon values as fundamental as... the nature of mathematics, the nature of teaching and learning, and the understanding of the role of the teacher" (Leung, 2001, p. 46), provide the key to understanding classroom practice and explaining the superior student achievement in East Asia.

4. CONCLUSION

The purpose of international studies of student achievements should not be for compiling a league table of countries in terms of their students' achievements. Their real value lies in seeking factors in explanation of student achievement, among which the most significant may be those concerning classroom practice. As the TIMSS 1999 Video Study indicates, classroom practices are deeply rooted in the underlying cultural values of the classroom and the wider society.

If East Asian instructional practices and the resulting high achievement of East Asian students are so much related to the underlying culture, what are the implications of this study? First, simple transplant of educational practice from high achieving countries to low achieving ones would not work. Since the teachers and their teaching are so much influenced by the underlying cultural value of the place, one cannot transplant the practice without transplanting the culture as well. What we can learn from another culture through comparative studies is to identify not only the superficial differences in educational practice, but the intricate relationship between the educational practice and the underlying culture of other

countries. Through studying these relationships in different cultures, we may then begin to understand the interaction between educational practices and culture, and through identifying the commonality and differences of both the educational practices and the underlying cultures, we may then determine how much can or cannot be borrowed from another culture.

ACKNOWLEDGMENTS

This paper is based on a research supported by the Fulbright Hong Kong Scholar Program 2002–2003.

NOTES

1. 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.
2. The 1995 Japanese data were re-analysed using the 1999 methodology in some of the analyses.
3. Within a country, the probability that a school being chosen is proportional to the size of the school as measured by the number of eighth grade students in the school. Then a class is randomly chosen from each of the schools sampled.
4. Since this same group of experts performed a similar analysis on the 1995 TIMSS Video data, which included the Japanese data, the 1999 Japanese data was not included in this analysis.
5. Since lesson duration varies across countries, the lesson time reported here is standardized to 50 min.
6. The typical class size in East Asian countries is 40, so a ratio between teacher words and student words of 16:1 (in Hong Kong) is in effect a ratio of 640:1 as far as an individual student is concerned.
7. Given that only 20 lessons were chosen from each country, the results in this section of the paper need to be interpreted with care.
8. The 1995 Japanese lessons were not included in this analysis, and so the only East Asian country discussed here is Hong Kong.

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