

# UC Irvine

## UC Irvine Previously Published Works

### Title

Mathematics achievement of children in China and the United States.

### Permalink

<https://escholarship.org/uc/item/16z2r4qv>

### Journal

Child development, 61(4)

### ISSN

0009-3920

### Authors

Stevenson, HW

Lee, SY

Chen, CS

et al.

### Publication Date

1990-08-01

### DOI

10.1111/j.1467-8624.1990.tb02841.x

### License

<https://creativecommons.org/licenses/by/4.0/> 4.0

Peer reviewed

## Mathematics Achievement of Children in China and the United States

**Harold W. Stevenson, Shin-ying Lee, Chuansheng Chen,  
and Max Lummis**

*University of Michigan*

**James Stigler**

*University of Chicago*

**Liu Fan and Fang Ge**

*Chinese Academy of Sciences*

STEVENSON, HAROLD W.; LEE, SHIN-YING; CHEN, CHUANSHENG; LUMMIS, MAX; STIGLER, JAMES; FAN, LIU; and GE, FANG. *CHILD DEVELOPMENT*, 1990, 61, 1053–1066. First and fifth graders in Beijing and Chicago were given a battery of mathematics tests. Whether tested with problems requiring solely computation or with ones requiring application of knowledge about mathematics, American children's performance was consistently inferior to that of Chinese children. Interviews with American children suggested that they like mathematics, believe they are doing well in mathematics, and do not perceive mathematics as a difficult subject. American children's poor performance appears to be attributable, in part, to low motivation for devoting more attention to mathematics. Low standards held by American parents for academic achievement and lower interest in teaching mathematics by American teachers appear to contribute to American children's poor performance.

Reports of American students' weaknesses in mathematics appear regularly in the popular and scientific press. Among these, the reports of cross-national studies of mathematics achievement have been especially disturbing. These studies document the profound underachievement in mathematics of American students compared to their peers in other countries. American secondary school students consistently demonstrated low average levels of performance in both the First and Second International Mathematics Studies (Garden, 1987; Husen, 1967). Moreover, our recent research in the United States, Japan, and Taiwan indicated that deficiencies among American children appear as early as kindergarten and persist throughout elementary school (Stevenson, Lee, & Stigler, 1986).

Because Japanese students have been among the top scorers in the cross-national studies, discussions of mathematics achieve-

ment inevitably lead to comparisons between the United States and Japan. These two highly industrialized countries devote considerable resources to education. We know little, however, about what occurs in countries that also value education highly but are unable to provide the economic support available in industrialized countries. China is such a country. It has a long tradition of reverence for education, but ranked below the median of other developing countries in a recent survey of the percentage of GNP devoted to educational expenditures (World Bank, 1985).

No data about children's academic achievement or its correlates have been available for children in China other than those derived from informal observations of visitors to Chinese classrooms (e.g., Kessen, 1976). The common observation is that teachers are spirited and energetic and the children are dedicated and enthusiastic. Visitors have

This research was supported by the William T. Grant Foundation and National Science Foundation grant MDR 8751390. We are greatly indebted to the children, parents, teachers, and school officials who cooperated with us in this study, and to the many examiners and coders who helped in obtaining the results. We especially want to thank Tong Lequan of the Chinese Academy of Social Sciences, and David Uttal, Michelle Perry, and William Bacon, colleagues at the University of Michigan. Send requests for reprints to the first author at Center for Human Growth and Development, University of Michigan, 300 N. Ingalls, 10th Level, Ann Arbor, MI 48109-0406.

[*Child Development*, 1990, 61, 1053–1066. © 1990 by the Society for Research in Child Development, Inc. All rights reserved. 0009-3920/90/6104-0005\$01.00]

## 1054 Child Development

been impressed by the apparent high levels of academic and social competence of Chinese children, but no data are available with which to evaluate the validity of these impressions.

Our focus in this report is on comparisons of mathematics achievement of elementary school children in the United States and China. The research offers a much more comprehensive survey of children's achievement in mathematics than was the case in our earlier research in Japan, Taiwan, and the United States (e.g., Stevenson et al., 1986). In the earlier research, we used a single test to evaluate children's achievement in mathematics. Although the test contained both computation and word problems, we did not sample the broad domain of mathematical knowledge. It is possible that American elementary school children possess strengths in mathematics, such as greater understanding of mathematical operations, ability to estimate outcomes, and skill in applying number concepts that were not assessed in the single test we used earlier. We therefore constructed a battery of tests to provide a detailed picture of American and Chinese children's performance in mathematics. In addition to testing children, we obtained information from the children and from their mothers, fathers, and teachers about factors that might influence children's performance in mathematics. Many factors were explored in the interviews, but we deal here with only one of them: attitudes about mathematics and mathematics achievement.

There is a growing literature suggesting that children's achievement is related to the attitudes held by the children, their parents, and teachers. This has been found to be true in studies of children within the United States (e.g., Eccles, 1983; Parsons, Kaczala, & Meece, 1982) and in comparative studies involving Japan, Taiwan, and the United States (e.g., Holloway & Hess, 1985; Lee, Ichikawa, & Stevenson, 1987). In the present study, we examined factors such as children's attitudes about how well they were doing in mathematics and how easy mathematics was for them, parents' attitudes about children's achievement in mathematics and the level of achievement with which they would be satisfied, and teachers' attitudes about teaching mathematics.

### Method

*Subjects.*—The children lived in Chicago and Beijing, two of the largest metropoli-

tan areas in their respective countries. It is critical in comparative studies that the samples of children included in a study be representative of the children residing in each location. To accomplish this goal, we sampled first on the basis of schools within the metropolitan areas and then we sampled children within these schools. Decisions about the specific schools to include in the study were made on the basis of demographic information and advice provided by local educational authorities.

We believed that 20 schools were necessary to encompass the ethnic and socioeconomic diversity of the population of the Chicago metropolitan area (i.e., Cook County). The sample of schools was chosen so that the proportion of public and private schools and of schools serving each ethnic and socioeconomic group would parallel the proportions existing within the metropolitan area.

Because of the greater homogeneity of the population in Beijing, we included children from 11 schools. Our sample was selected to represent the range of schools in terms of region within the city and of socioeconomic and educational status of the families served by the schools. Included within the sample was one "key" school, where children are selected on the basis of their high academic achievement. Instruction in all Beijing schools is conducted in *putonghua* (Mandarin Chinese), and all Beijing children are able to speak this dialect of Chinese.

Within each school we selected two classrooms at first grade and two classrooms at fifth grade. The 3,607 children (1975 from Chicago and 1632 from Beijing) from the 124 classrooms constituted the full sample for the study. Because it was impossible to interview and test over 3,600 children individually, part of the study was conducted with a subsample constituted by selecting three boys and three girls at random from each of the classrooms. This procedure yielded a total of 480 children in Chicago and 264 children in Beijing.

Some of the salient demographic characteristics of the families included in this study are the following. The average number of years of education of Chicago mothers was 12.8 (SD = 3.5), and of Chicago fathers, 13.5 (SD = 3.7). In Beijing, the average for the mothers was 10.2 years (SD = 3.3), and for fathers, 11.5 years (SD = 3.5). The median income of the families in Beijing, derived from an assumed average of three wage earn-

ers per family, was 2,500 yuan (\$778) per year, with a range from 1,100 to 5,400 yuan. The income of the Chicago families varied from zero to more than \$60,000, with a median of \$32,500. There were nearly as many families with incomes below \$10,000 as there were families with incomes above \$60,000, but the majority, 73.4%, fell between these two extremes. Among Chicago families, 93% of the fathers and 51% of the mothers were employed; the corresponding percentages in Beijing were 98% for each parent. In Beijing families, there was an average of 1.3 children, and in Chicago, 2.8. Over 99% of the children in Beijing and 76% of the children in Chicago came from intact families. One or more grandparents were living with 50% of the Beijing families and with 10% of the Chicago families.

Nearly all of the Chinese children (90%) were born in Beijing, and 97% had spent their childhoods in Beijing. The Chicago sample was composed of 24% black, 15% Hispanic, 4% Asian-American, and 55% white children. Most of the Hispanic parents (69% of the mothers and 79% of the fathers) were foreign-born, but nearly all black parents (95%) and most of the white parents (88%) were born in the United States. Spanish was spoken in the home by most of the Hispanic families (84%), but only 13% of the white families and 2% of the black families spoke a language at home other than English.

Attendance at elementary school is compulsory in both Beijing and Chicago, but the age at entrance to school differs. At each grade, therefore, children in Beijing were somewhat older than the children in Chicago. The mean ages at first grade were 6.4 (Chicago) and 6.9 (Beijing) years, and the standard deviations were .4 years in each case; in fifth grade, the mean ages were 10.5 (Chicago) and 11.2 (Beijing) years, and the standard deviations, .5 years.

*Achievement tests.*—In cross-national studies, the tests of academic achievement must be relevant to the children's experiences in each culture. To ensure that this was the case, it was necessary for us to gain a thorough knowledge of the content of the respective curricula in mathematics. We accomplished this by conducting an analysis of the single textbook series used in Beijing and two of the mathematics series (Holt; Scott-Foresman) used most commonly in the United States. Problems and tests were then designed on the basis of a file that contained a list of every concept and skill introduced each semester in the sets of textbooks.

We relied on two sources of information in constructing the tests: the content of the textbooks and the opinions of mathematics educators from the two countries. Our major concern was that children had been exposed to the concepts and skills that we sought to evaluate. The items were based on, but not identical to, those that appeared in the textbooks. Our major task was to place items at points in the tests where they were fair assessments of what the children should have learned. This was not especially difficult, for there were not large discrepancies in the year in which the concepts and skills were introduced into the Chinese and American textbooks. The order followed a sequence of difficulty derived from the first appearance of the concept or skill in the children's textbooks. When the test tapped skills, such as visualization, that were not a central part of the mathematics curriculum, the order was based on the opinions of mathematics educators. The content of the Chinese and American tests was identical except for the language used. Because both countries use Arabic numerals, it was necessary to change only details such as names and units of measurement so that they would be appropriate for each culture.

The tests were constructed by a team of researchers that included graduate students and professional colleagues from China and the United States. The tests were scored by Chinese and American graduate students. Each test was scored twice, and when questions or disagreements arose in scoring, they were resolved through discussions involving all individuals scoring the tests.

A group test of computation was administered to all of the children enrolled in the 124 classrooms visited. The 76 test items were arranged in order of difficulty, beginning with those at the kindergarten level and continuing through items beyond the sixth-grade level. First graders started with kindergarten items and fifth graders started with third-grade items. The children were allowed 20 min to solve as many problems as possible. A group test of geometry containing 17 items was also given in all fifth-grade classrooms. The children were allowed 20 min for this test.

The nine remaining tests tapped proficiency in other mathematical skills. These tests were administered individually to the subsample of children. We included many of the skills that, on the basis of our analysis of textbooks and consultation with mathematics educators, we believe elementary school children should possess. Elementary school children should understand basic mathematical

## 1056 Child Development

operations and should be able to apply their knowledge in the solution of meaningful problems; they should demonstrate facility with number concepts, comprehend information contained in graphs and tables, and possess skill in estimation and measurement; they should have a good sense of spatial relations and be able to visualize transformations in the orientation of objects; and they should be able to solve mathematical problems with reasonable speed. These fundamental areas of knowledge and skill were explored in nine tests. Each test began with easy items and progressed to more difficult ones. The examiner read each problem to the child and provided the child with a printed version of the problem. (Examiners and interviewers from each ethnic group were employed for the study.) The child was allowed to use paper and pencil throughout the testing. Each test is described in detail in Stigler, Lee, and Stevenson (in press), but brief descriptions are given here and examples appear in Table 3.

1. Word problems: The problems were read to the child and were of the types children in both China and the United States frequently encounter in mathematics classes.

2. Number concepts: The children were required to demonstrate that they understood basic number concepts, such as addition, fractions, and number lines, or to identify equations accurately reflecting the content of word problems or pictures.

3. Mathematical operations: The children were asked to demonstrate a knowledge of mathematical operations by activities such as identifying a subtraction problem, making up a word problem, and explaining addition.

4. Measurement and scaling: Children's understanding of numerical quantity and extent was tested in these problems. Many of the questions were multiple choice in which the child was to pick the alternative best described by a numerical quantity (e.g., "Pick one that is about 10 inches [20 cm in the Chinese version] long: a key, a man's shoe, a jumprope").

5. Graphs and tables: Questions were asked about values and information represented in graphs and tables. The content of the graphs and tables was read to the child, but the examiner did not explain their interpretation. For example, a table indicated the number of black and of white puppies owned by three children. Typical questions were,

"Who had the most puppies?" and "How many black puppies did Sarah have?"

6. Spatial relations: The children were asked to predict the form of a figure after a series of folds and cuts had been made in it. For example, two attached squares ( $b$  and  $c$ ) had a third square ( $a$ ) attached to the top of one,  $b$ . The child was to select the figure from among three that would be formed if  $a$  were folded over  $b$ , and  $c$  over  $a$ .

7. Visualization: The children were asked to predict the orientation of an object after a series of transformations or to select the element(s) that would restore the unity of a geometrical figure. For example, a corner of a square was missing and the child was asked to choose from among four alternatives the one that would restore the square.

8. Estimation: The test contained items such as one in which the children were asked to estimate the value of a point drawn on a line with endpoints of 80 and 100, or to estimate the number of dots appearing in a random distribution on a page.

9. Speed tests: In these tests of mental arithmetic, the child answered orally the solution to single-digit addition problems (Speed A), two-digit addition problems (Speed B), or problems involving multiplying a two-digit by a one-digit number (Speed C). One minute was allowed for each of the three tests. First graders were given only the set of problems in Speed A.

Three testing sessions were required: one for the group test(s) and two for the individually administered tests. Group testing was carried out during the third month of the 1985–1986 school year. The individually administered tests were given 3 months after the beginning of the second semester in Chicago and 5 months after the beginning of the second semester in Beijing. The later testing allowed Beijing children to have additional instruction and practice. Because of this advantage, we decided to test a second sample in Beijing at the same time in their school year as the American children had been tested. The children, 120 first graders and 120 fifth graders, were selected from the same schools in the same manner the children had been selected a year earlier. The tests (the computation test, geometry test, and five tests of the battery) were given 3 months after the beginning of the second semester in 1987. As will become evident, the differences between the Chicago and Beijing children were as striking in the second as in the first adminis-

tration of the tests in Beijing. The 2 months difference in time of testing did not, therefore, prove to be an explanation of Chicago-Beijing differences in mathematics achievement.

Cronbach alpha coefficients for the computation test at first grade were .64 (Beijing) and .85 (Chicago). At fifth grade, the respective values were .82 and .86. Reliabilities also were high for the two other tests with a large number of items, word problems and number concepts. The reliabilities ranged from .69 to .81 at first grade and from .63 to .85 at fifth grade. Reliabilities were not computed for three tests: mathematical operations, measurement, and estimation. These tests required diverse types of responses (e.g., multiple-choice, correct-incorrect, or estimated values), each of which was represented by a small number of items. The median reliability of the remaining tests was .68 at first grade and .51 at fifth grade.

*Interviews.*—We were able to arrange interviews with 98% of the mothers of children in the Beijing subsample and with 81% of the mothers in the Chicago subsample. It was not feasible to interview the fathers, but a questionnaire was left with the mothers for the fathers to fill out and return. Most of the Chinese fathers (89%), but only 35% of the American fathers, returned the questionnaire. The low response rate of American fathers is due in part to the fact that no father was present in approximately one-fourth of the homes. However, the low rate is of special significance in view of the fact that fathers in the intact families knew the study had the approval of their child's teacher and school principal and was relevant to issues concerning their child's education. American fathers who returned the questionnaire had a higher mean level of education than those who did not (14.3 vs. 12.8 years). In Chicago, interviews were conducted in Spanish when appropriate, and Spanish versions of the questionnaires for fathers were used when they were needed.

Interviews with the children took place during one of the two testing sessions held with the subsamples. Scales used in the interviews were typically represented by drawings for the first graders and by words for fifth graders. The interviewer tutored the child about the use of each scale. Children appeared to have no difficulty responding to the scales, most of which were 3-point scales for first graders and 5-point scales for fifth graders. All of the 124 teachers were interviewed after school hours.

## Results and Discussion

*Mathematics achievement.*—The results provide a bleak picture of American children's understanding of mathematics. There were almost no areas in which the Chicago children performed as well as the children in Beijing. The deficiencies of American children were pervasive (see Table 1). In nearly all comparisons, scores of the American children were significantly below those of the Chinese children. (All analyses were 2 [country]  $\times$  2 [sex] analyses of variance.) The two exceptions in which the difference between the means for Chicago and Beijing children was not significant were for the visualization and graphs and tables fifth-grade tests. In no comparison did American children perform significantly better than the Chinese children.

Chinese children not only solved problems effectively, they also solved them rapidly. In first grade, they solved nearly three times as many single-digit addition problems (Speed A) as the American children. Chinese fifth graders solved half again as many single-digit problems as the American fifth graders, and on the more difficult tests (Speed B and C), they solved twice as many problems.

All differences were also highly significant when comparisons were made between the scores of American children and the second sample of Chinese children, those children who had received the same amount of schooling as the American children at the time of testing. This was true for the group test of computation at first and fifth grades and the geometry test at fifth grade,  $F's(1,1693-1,1685) = 22.60-5942.60$ ,  $p's < .001$ . It was also true for the individually administered tests selected for the replication study (word problems, number concepts, visualization, measurement, and the speed tests),  $F's(1,336-1,354) = 20.91-231.16$ ,  $p's < .001$ .

Each child's scores on both the group and individual tests were transformed into  $z$  scores in order to facilitate comparisons among tests. The  $z$  score represents the departure in standard deviation units from the weighted mean of a distribution derived at each grade level from the scores of the children in the two cities. The Beijing sample was weighted twice as heavily as the Chicago sample in computing the  $z$  scores. The mean score for each location was then determined by recombining scores for each child on each test according to country. These mean scores appear in Figure 1. It is evident that the

TABLE 1  
MEAN SCORES (+ SD) ON THE MATHEMATICS TEST FOR GRADES 1 AND 5

|                              | Beijing     | Chicago     | F          | Total Possible Score |
|------------------------------|-------------|-------------|------------|----------------------|
| First grade:                 |             |             |            |                      |
| Computation .....            | 18.1 (2.5)  | 13.0 (3.6)  | 1152.79*** | 41                   |
| Word problems .....          | 9.2 (2.5)   | 3.6 (2.4)   | 394.96***  | 28                   |
| Mathematical operations .... | 11.5 (2.0)  | 5.8 (2.7)   | 396.67***  | 18                   |
| Number concepts .....        | 20.4 (3.2)  | 15.0 (4.5)  | 136.54***  | 30                   |
| Measurement .....            | 6.7 (1.7)   | 5.6 (1.8)   | 31.64***   | 13                   |
| Estimation .....             | 6.4 (2.9)   | 4.7 (2.6)   | 31.81***   | 18                   |
| Graphs and tables .....      | 5.1 (1.9)   | 3.6 (2.1)   | 42.25***   | 9                    |
| Visualization .....          | 7.8 (1.5)   | 7.3 (1.9)   | 5.93*      | 13                   |
| Spatial relations .....      | 5.4 (2.6)   | 4.0 (2.2)   | 27.17***   | 10                   |
| Speed A .....                | 30.5 (9.1)  | 9.1 (5.3)   | 806.26***  | 81                   |
| Fifth grade:                 |             |             |            |                      |
| Computation .....            | 57.5 (4.8)  | 45.7 (6.6)  | 1757.83*** | 78                   |
| Word problems .....          | 18.3 (3.8)  | 12.7 (3.8)  | 172.82***  | 28                   |
| Mathematical operations .... | 13.4 (2.1)  | 8.9 (2.7)   | 251.33***  | 21                   |
| Number concepts .....        | 28.2 (3.1)  | 21.1 (5.6)  | 161.90***  | 34                   |
| Measurement .....            | 10.2 (1.7)  | 8.8 (1.8)   | 54.03***   | 13                   |
| Estimation .....             | 14.7 (3.3)  | 12.5 (3.4)  | 33.12***   | 26                   |
| Graphs and tables .....      | 6.5 (1.6)   | 6.9 (1.8)   | n.s.       | 9                    |
| Visualization .....          | 10.7 (2.0)  | 10.5 (1.8)  | n.s.       | 15                   |
| Spatial relations .....      | 7.5 (1.7)   | 7.0 (2.0)   | 6.88**     | 10                   |
| Speed A .....                | 52.6 (11.3) | 33.2 (11.7) | 209.04***  | 81                   |
| Speed B .....                | 18.1 (6.0)  | 7.9 (4.7)   | 310.71***  | 72                   |
| Speed C .....                | 9.8 (4.3)   | 4.3 (2.7)   | 203.51***  | 48                   |
| Geometry .....               | 10.3 (2.1)  | 4.3 (1.7)   | 4694.10*** | 17                   |

NOTE.—Sample sizes for computation and geometry tests: Chicago, 976 (grade 1), 999 (grade 5); Beijing, 801 (grade 1), 831 (grade 5). Range of sample sizes for remaining tests for grade 1: Chicago, 231–236; Beijing, 115–118; grade 5: Chicago, 208–235; Beijing, 119.

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .001$ .

scores of Chinese children exceeded those of Chicago children in nearly every comparison. The same types of comparisons were made for the speed tests given to the first graders (Speed A) and to the fifth graders (Speeds A, B, and C) in Figure 2. Again, large differences between the scores of the Beijing and Chicago children are evident.

Another way of assessing the differences in the competence of Chinese and American children in mathematics is to ask how many Chinese children would obtain a score at or below the mean score of the American children. When we did this, we found that on the computation test, only 2.2% of the Chinese first graders and 1.4% of the Chinese fifth graders obtained a score at or below the mean for their American counterparts. That is to say, of 100 of the Beijing children, roughly 98 children were above average according to the Chicago data. A similar picture emerged from comparisons of the other tests. In the word-problems test, for example, only 2.6% of the

Chinese first graders and 10% of the Chinese fifth graders obtained a score at or below the American means. Comparable percentages for the number concepts test were 6.7% at first grade and 3.3% at fifth grade.

Differences occurred not only on difficult items but were distributed throughout the range of problems. The examples of individual items given in Tables 2 and 3 are illustrative of the differences between the performance of the American and Chinese children.

Variability among Chicago schools in the children's average levels of performance was much greater than among schools in Beijing. This is illustrated in Figure 3, where the average scores ( $\pm 1$  SD) for the computation test are plotted according to grade and school. Even more impressive than the differences in the range of the means is the degree of separation between the schools in Chicago and in Beijing. At first grade, there was no overlap in the mean scores for the two cities. At fifth

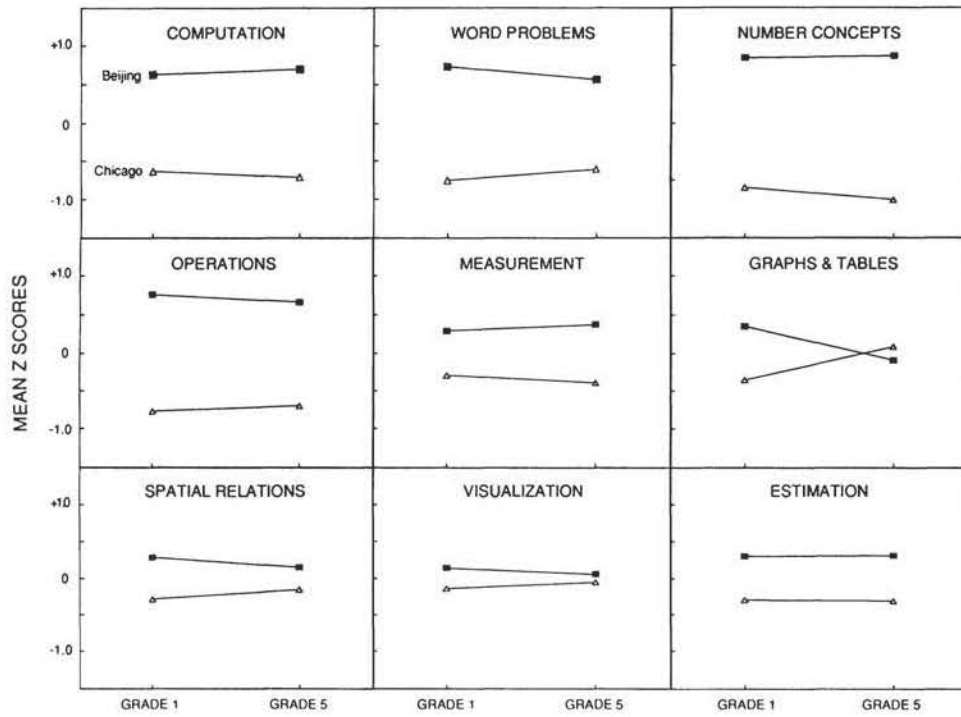


FIG. 1.—Children's performance on the tests of mathematics

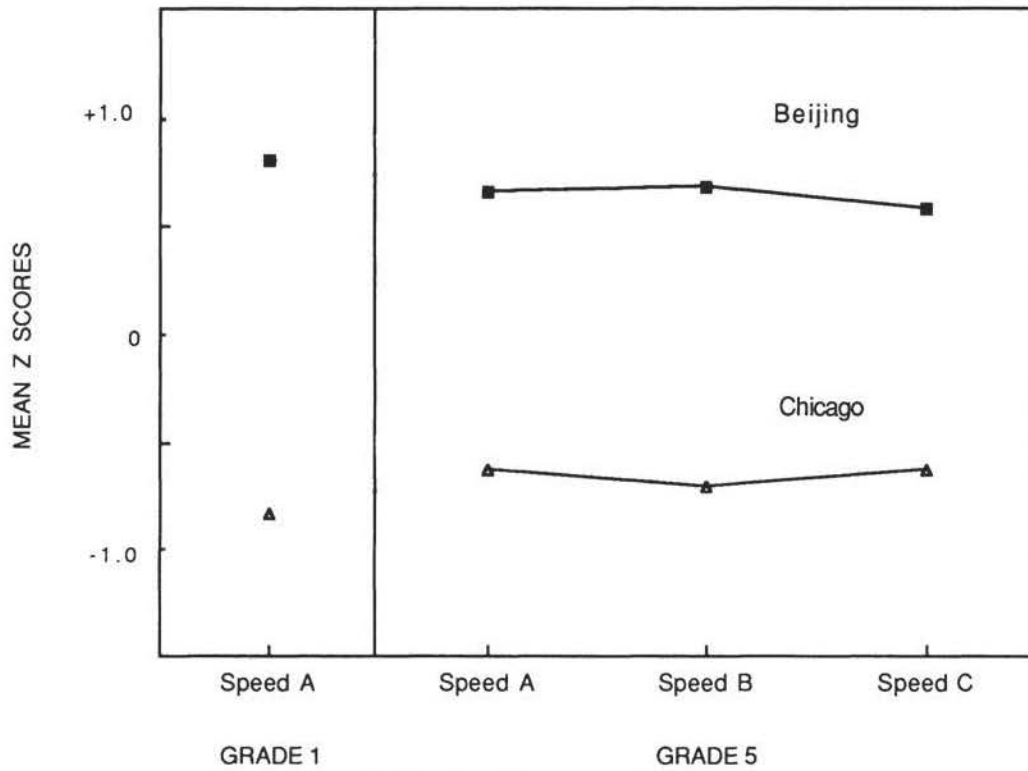


FIG. 2.—Children's performance on the speed tests



## 1060 Child Development

TABLE 2  
EXAMPLES OF ITEMS FROM GROUP COMPUTATION  
TEST (Percent Correct)

|                                   | Beijing | Chicago |
|-----------------------------------|---------|---------|
| First grade:                      |         |         |
| 9 - 1 .....                       | 99.6    | 51.8    |
| Count 17 dots .....               | 96.5    | 78.3    |
| 5 + 4 .....                       | 99.6    | 77.2    |
| 19 + 45 .....                     | 27.2    | 6.5     |
| Fifth grade:                      |         |         |
| — - 34 = 32 .....                 | 96.1    | 29.4    |
| 13 ÷ 13 = .....                   | 99.8    | 70.2    |
| $\frac{3}{8} + \frac{2}{8}$ ..... | 55.1    | 38.6    |
| .08 × 10 .....                    | 78.7    | 20.5    |

grade, only one Chicago school had a mean score as high as the lowest-scoring Beijing school. These differences are as great as the differences in performance in mathematics that we noted between elementary school children in Minneapolis and in Taiwan and Japan (Stevenson et al., 1986). A further illustration of the degree of separation between

the schools in Chicago and in Beijing appears in Figure 4, where data from the word problems are presented in the same fashion as the data are presented in Figure 3.

There are two likely explanations of the large variability among the Chicago schools. First, the preferences of teachers play a more important role in determining what is taught in mathematics classes and the time that is devoted to mathematics in the United States than is the case in China, where teachers follow a national curriculum. In our earlier research involving over 600 hours of observation in 20 fifth-grade American classrooms, we found that some American fifth-grade teachers devoted as much as 40% of their time to mathematics while others were never observed to be teaching mathematics (Stevenson et al., 1987). A second explanation of the greater variability among Chicago schools is that the neighborhoods in which the schools were located in the Chicago metropolitan area ranged from upper-middle-class suburbs to economically disadvantaged areas of the inner city. In Beijing, the educational and economic status of the families of children at

TABLE 3  
EXAMPLES OF ITEMS FROM INDIVIDUAL TESTS (Percent Correct)

|  | Beijing | Chicago |
|--|---------|---------|
| First grade:   |         |         |
| There were 15 bunnies. 9 hopped away. How many bunnies were left?<br>(Word problems) .....   | 95.8    | 30.1    |
| Chris has 26 toy cars. Mary has 19. How many do they have in all?<br>(Word problems) .....   | 84.7    | 13.1    |
| Suppose you are a teacher and you want to make up some questions.<br>What kind of word problem would you make up using these numbers:<br>5 + 2 = (Mathematical operations) .....         | 89.8    | 43.2    |
| The child was asked to draw a circle around one-half of a group of stars<br>arranged randomly in two lines. (Number concepts) .....  | 44.9    | 10.7    |
| An X was marked midway on a line whose endpoints were 0 and 10.<br>The child was asked to estimate the number for X. (Estimation) .....  | 57.6    | 15.8    |
| Fifth grade:   |         |         |
| The teacher gave 3 sheets of paper to each of 9 people. There are still 2<br>sheets of paper left. How many sheets of paper did the teacher have<br>when he began? (Word problems) ..... | 91.6    | 43.4    |
| A stamp collecting club has 24 members. Five-sixths of the members col-<br>lect only foreign stamps. How many collect only foreign stamps?<br>(Word problems) .....                      | 58.8    | 8.9     |
| Ten cans of pop cost \$1.50 at one store. I can get 5 cans for 80 cents at a<br>second store. Where is the pop cheaper? The first or the second store?<br>(Number concepts) .....        | 80.7    | 38.0    |
| Chris and Kim are standing next to each other. It takes Chris 7 steps to<br>get to the door, and it takes Kim 9 steps. Who takes bigger steps?<br>(Measurement) .....                    | 91.6    | 55.1    |

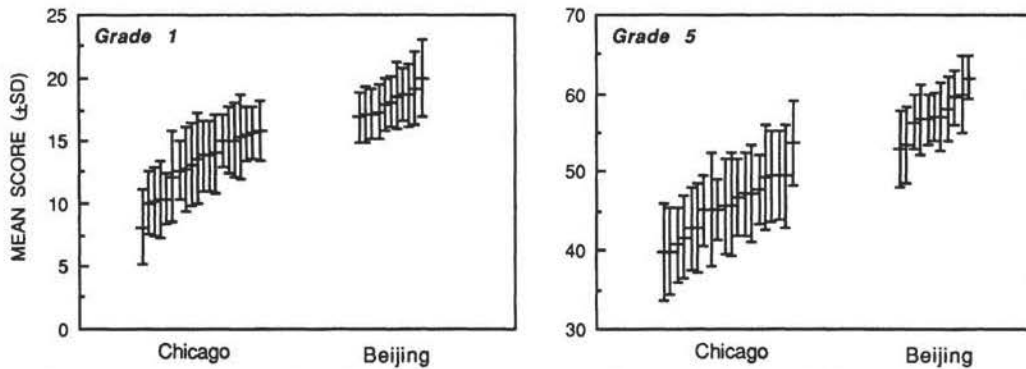


FIG. 3.—Average scores ( $\pm 1$  SD) on the computation test for each school in Beijing and Chicago

tending different schools was much more uniform.

The selection of a metropolitan area such as Chicago inevitably brings up the question of the possible influence of ethnic status on performance. This is discussed in detail in a forthcoming article (Stevenson, Chen, & Uttal, in press), but the comparison of special interest here is the performance of the Asian-American children in the Chicago schools. There were a sufficient number of Asian-American children for statistical analysis only in the computation and geometry tests. Asian-American and white children scored significantly higher on the computation test than black and Hispanic children at first grade. At fifth grade, Asian-American children scored significantly higher than white and black children, who in turn scored significantly higher than the Hispanic children. The mean scores at first grade were 14.3 (Asian-American), 14.0 (white), 11.5 (Hispanic), and 11.2 (black). At fifth grade, the means were 51.3 (Asian-American), 46.3 (white), 44.9 (black), and 43.7 (Hispanic). In fifth-grade geometry, Asian-American children scored significantly higher

than white children, who in turn received significantly higher scores than black and Hispanic children. The respective means were 5.6, 4.6, 3.7, and 3.8. All of the above analyses of variance were highly significant,  $F$ 's(3,894–3,956) = 15.11–48.13,  $p$ 's < .001.

Although Asian-American children received the highest scores among the four ethnic groups of American children, their scores were significantly lower than those of children in Beijing. For example, on the computation test, the Asian-American first graders had an average score of 14.3, but the average score of the Beijing children was 18.1. At fifth grade, the respective means were 51.3 and 57.4. In geometry, the mean score for the Asian-American children was 5.6, and for the Beijing children, 10.3. These differences were highly significant,  $F$ 's(1,832–1,861) = 48.23–157.66,  $p$ 's < .001. It is evident from these data that the superiority of Asian students in mathematics carries over—but only to a degree—to Asian-American students.

The data provide an opportunity to assess the similarity between the two cultures in

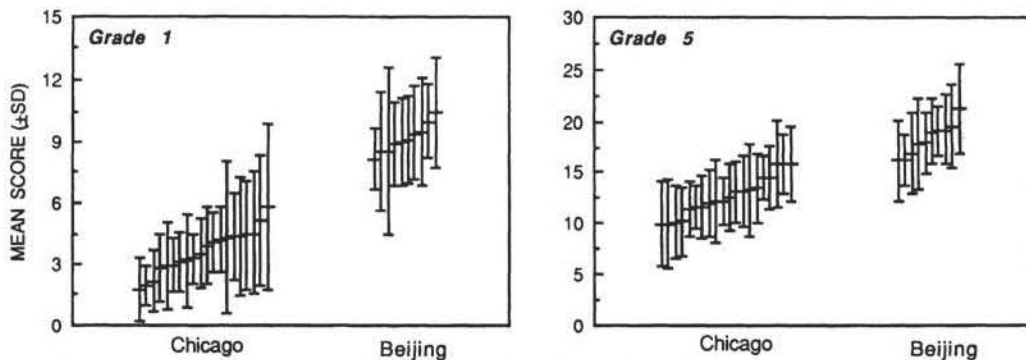


FIG. 4.—Average scores ( $\pm 1$  SD) on the word problems for each school in Beijing and Chicago

TABLE 4  
MEAN SCORES (+ SD) FOR SIGNIFICANT SEX DIFFERENCES

|                         | BEIJING    |             | CHICAGO    |            |
|-------------------------|------------|-------------|------------|------------|
|                         | Boy        | Girl        | Boy        | Girl       |
| First grade:            |            |             |            |            |
| Measurement .....       | 7.1 (1.9)  | 6.3 (1.4)   | 5.8 (1.9)  | 5.4 (1.8)  |
| Estimation .....        | 6.4 (2.8)  | 6.5 (3.1)   | 5.2 (2.8)  | 4.3 (2.3)  |
| Graphs and tables ..... | 5.4 (2.0)  | 4.8 (1.8)   | 3.8 (2.3)  | 3.3 (1.9)  |
| Visualization .....     | 8.2 (1.5)  | 7.5 (1.5)   | 7.5 (1.9)  | 7.1 (1.8)  |
| Speed A .....           | 28.2 (6.8) | 32.8 (10.4) | 9.6 (5.9)  | 8.5 (4.5)  |
| Fifth grade:            |            |             |            |            |
| Word problems .....     | 19.1 (3.9) | 17.6 (3.6)  | 13.1 (4.0) | 12.4 (3.5) |
| Measurement .....       | 10.7 (1.7) | 9.8 (1.5)   | 9.0 (1.7)  | 8.6 (1.9)  |
| Estimation .....        | 15.7 (2.9) | 13.7 (3.5)  | 12.9 (3.3) | 12.2 (3.5) |
| Visualization .....     | 11.0 (2.0) | 10.5 (2.0)  | 10.8 (1.7) | 10.4 (1.8) |

possible sex differences in mathematics. Sex differences were not significant at either grade in either city for the computation test. In geometry, there were no significant sex differences in Chicago, but in Beijing boys received higher scores than girls,  $F(1,829) = 14.36$ ,  $p < .001$ . On the individual tests, the scores of boys exceeded those of girls in both countries at both grades on measurement, estimation, and visualization; at first grade on reading graphs and tables; and at fifth grade on word problems,  $F's(1,340-1,350) = 4.60-10.32$ ,  $p's < .05$ . The mean scores for boys and girls on these tests are presented in Table 4. All but the word problems test involve visual representation of spatial relations, an area in which the superiority of boys is often noted (e.g., Maccoby & Jacklin, 1974). However, why boys should also be better at word problems is not clear, for boys and girls did equally well on tests that involve knowledge underlying the solution of word problems, such as mathematical operations and number concepts.

The only significant interaction between country and gender other than that found for geometry was at first grade for Speed A,  $F(1,344) = 12.05$ ,  $p < .01$ . Boys completed more problems than girls in Chicago, but Beijing girls completed more problems than Beijing boys. In nearly all cases, therefore, the magnitude and direction of sex differences in performance were equivalent in the two countries.

*Children's attitudes about mathematics.*—The argument that poor performance can often be attributed to a lack of interest does not explain American children's low levels of achievement in mathematics. The majority of the American children liked math-

ematics, thought they were doing well in mathematics, and wished to learn more about mathematics.

When asked to rate how well they liked mathematics on a five-point scale ranging from "don't like mathematics at all" to "like mathematics very much," 72% of the American first and fifth graders and 85% of the Chinese children indicated that they liked mathematics. American children expressed an interest in mathematics in other ways. When they were asked what they would want to learn about if they had a whole day to learn something new, 22% of the American children, as contrasted with 8% of the Chinese children, spontaneously mentioned mathematics. In another more direct question, we asked the American children: "Let's say a wizard could make you better in math or reading. If you had your choice, which would you choose to be better in?" The majority of American children (63%) chose mathematics.

We believe that a major reason American elementary school children have positive attitudes about mathematics is because they consider mathematics to be an easy subject. In their ratings of how difficult mathematics was for them, only 8% of the American children, but 20% of the Chinese children, indicated that mathematics was "hard" or "very hard." Children in both cities who thought mathematics was easy were more apt to like mathematics. The correlations for first graders were .27 (Chicago) and .36 (Beijing), and for fifth graders, .31 and .25,  $p's < .01$ .

American children also had very positive images of their mathematics achievement. When asked to rate how well they thought they were doing in mathematics compared to other children in their class, more American

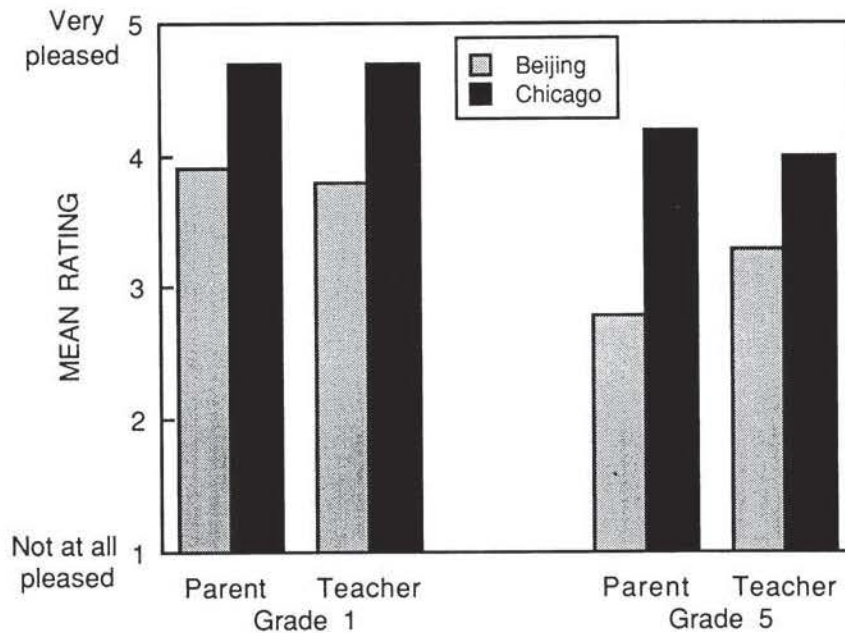


FIG. 5.—Children's ratings of how pleased their parents and teachers were with their performance in mathematics.

than Chinese children (52% vs. 39%) chose the alternatives "above average" or "among the best" on a 5-point scale where 3 was "average." American children also were optimistic about their future performance in mathematics. Among American first graders, 75% indicated that next year they would be among the "best" students, as contrasted with being among the "middle" or "worst" students. Only 50% of the Chinese first graders were this confident. Similarly, 58% of the American fifth graders expected to be above average or among the best students in mathematics in high school, a percentage much higher than that of their Chinese peers, among whom 29% made these choices. Despite the American children's high self-evaluations, they were sensitive about their own status in relation to that of their classmates. Correlations between their self-evaluations of their performance in mathematics and their actual mathematics achievement, as represented by a composite score including computation, word problems, and number concepts, were significant at fifth grade in both Chicago,  $r = .35$ ,  $p < .001$ , and Beijing,  $r = .28$ ,  $p < .01$ .

American children not only thought mathematics was easy, they also thought they were meeting their parents' expectations concerning their achievement in mathematics. Compared to 55% of the Chinese children, 89% of the American children thought their

parents were pleased with their performance. The great majority of American children also believed their teachers were pleased. The mean ratings of how pleased their parents and teachers were with their performance in mathematics appear in Figure 5. All of the cross-national differences were highly significant,  $F_s(1,343-1,352) = 55.34-166.74$ ,  $p's < .001$ . Responses from their mothers and fathers indicated that these were valid perceptions.

*Parents' attitudes.*—American mothers expressed strongly positive attitudes about their child's performance; 35% of the American mothers, but only 13% of the Chinese mothers, thought their child was doing "very well" in mathematics—the highest value on a five-point scale. This is in line with the large percentage of American mothers and fathers who were satisfied with their child's general level of achievement in school (see Fig. 6). Most American parents were satisfied and few expressed dissatisfaction. Chinese parents were much more critical. Less than half of the Chinese parents were satisfied with their child's academic performance, and at least one out of five was dissatisfied. With such high levels of satisfaction among American parents, it is not surprising that the American children believed they were making appropriate progress in school. The cross-national differences were all highly signifi-

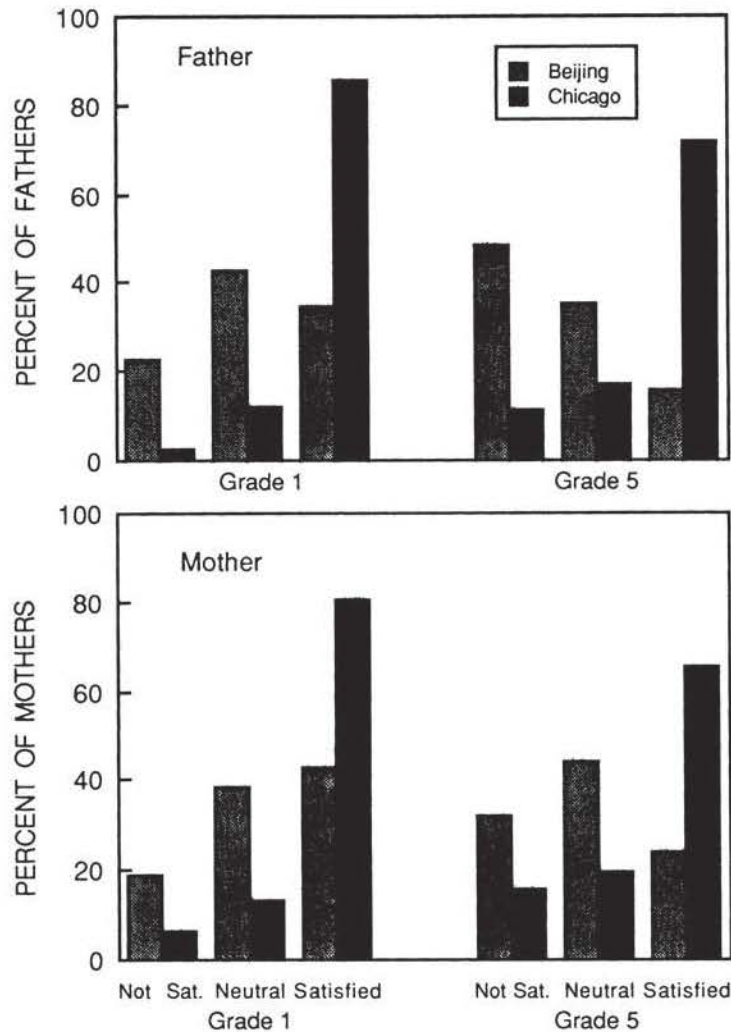


FIG. 6.—Mothers' and fathers' attitudes about their child's performance in school

cant,  $\chi^2(4, N = 244-518) = 86.99-107.52, p's < .001$ .

We interpret the high level of satisfaction among American parents as being the result of the low standards they hold for their children's academic achievement. Support for this interpretation appeared in the following situation. Parents were asked, "Let's say that your child took a math test for his/her grade level with a maximum of 100 points. The average score was 70. What score do you think your child would get? What is the least number of points you would be satisfied with?" The predictions made by American and Chinese mothers and fathers of first graders thought their child would obtain a higher score than

did the American parents; the first of these effects was significant,  $F(1,514) = 31.30, p < .001$ . American fathers of fifth graders thought their child would obtain a higher score than did the Chinese fathers,  $F(1,249) = 6.58, p < .05$ . On the other hand, large cultural differences appeared in the average scores with which the parents would be satisfied (see Fig. 7). The average score with which American parents would be satisfied was a few points above 70. Chinese parents had higher aspirations; the average score with which they would be satisfied was in the high 80s or 90s. Cross-national differences were significant at both grades for comparisons of the scores with which the mothers and fathers would be satisfied,  $F's(1,236-1,514) = 63.91-441.91, p's < .001$ .

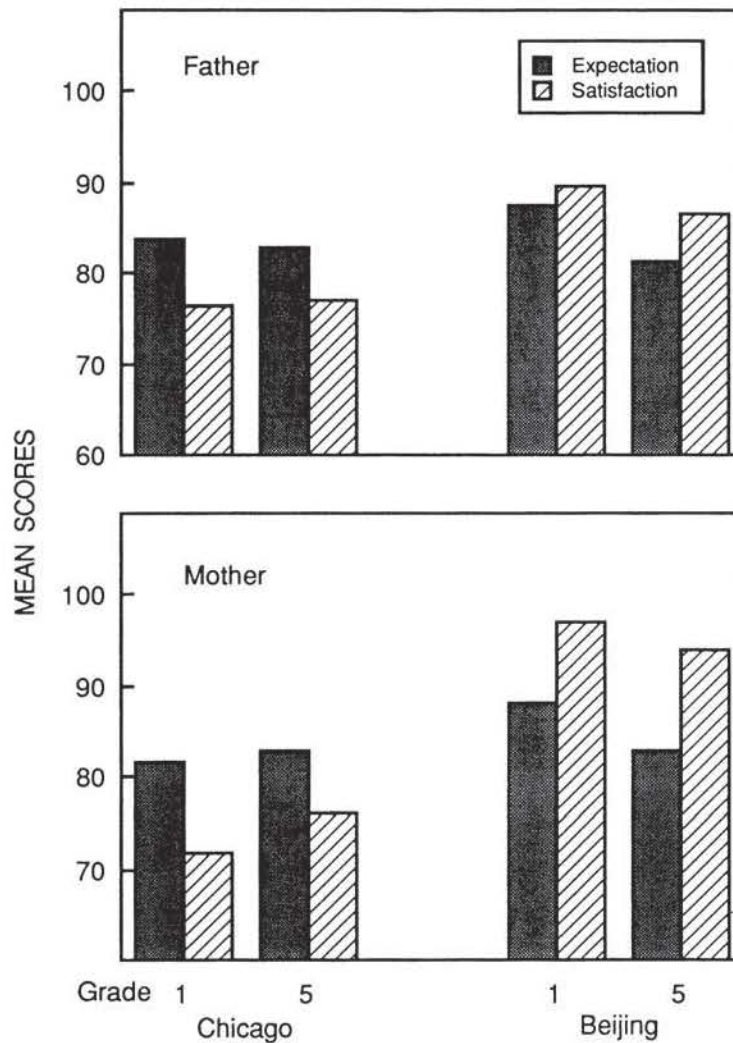


FIG. 7.—Scores mothers and fathers expected their child would obtain in a hypothetical mathematics test and the scores with which they would be satisfied.

*Teachers' attitudes.*—Children's attitudes about mathematics must also be influenced by those of their teachers. In general, mathematics held a lower status in the eyes of the American than of the Chinese teachers. Only 9% of the Chicago teachers, but 34% of the Beijing teachers, mentioned mathematics as the most important of all the subjects they teach. Moreover, when asked what subject they most liked to teach, only 32% of the Chicago teachers, but 61% of the Beijing teachers, said mathematics. Chicago teachers preferred to teach language arts (46%).

In a subsequent question, the teachers were asked about their skill in teaching. Fewer Chicago teachers thought they were

skilled in teaching mathematics than thought themselves skilled in teaching language arts (25% vs. 48%). Beijing teachers were equally divided between the two subjects (45% vs. 46%).

The difference in the attitudes of the teachers cannot be attributed to factors such as sex of teacher or educational level. The teachers were predominantly women in both locations: 94% in Beijing and 95% in Chicago. The educational level of the Chicago teachers was high; all held the bachelor's degree and 37% had received the master's degree. Most of the Chinese teachers (60%) had attended a teachers college for 2 or 3 years after graduating from high school; 37% had attended only high school.

## 1066 Child Development

### Conclusions

It is obvious from these data that American children's deficiencies in mathematics are pervasive. This was apparent neither to the American mothers, who believed that their children were doing well in mathematics, nor to the children themselves. We do not purport to say that children in all schools in China would perform as well as children in Beijing. Clearly, this is not the case. In China, no less than in the United States, differences exist between urban and rural schools and between schools that receive differing levels of financial support. What is evident, however, is that children in the Chicago metropolitan area were not competitive in the various aspects of mathematics with their peers in Beijing.

The data indicate that American children hold favorable attitudes about mathematics, but their poor performance suggests that these positive attitudes were not derived from a clear understanding of mathematics or an appreciation of its complexities. Rather, the American children believed that mathematics is easy and that they were doing well. These beliefs were supported by the positive attitudes of the American parents, who held a very favorable attitude about their children's accomplishments. The American children were as sensitive to differences among children's performance in mathematics as the Chinese children, but they generally had much more favorable views of their performance than would be merited in cross-national comparisons. This positive self-evaluation reflects, we believe, the lower standards held for children's performance in Chicago than in Beijing. Another critical factor in influencing American children's attitudes about mathematics was the teachers' deemphasis of the importance of mathematics. Children's motivation to work hard in school is influenced by the attitudes and evaluations of their parents and teachers. When we ask how American children's performance can be improved, it is necessary to acknowledge such differences in attitudes between the two countries. It will be difficult to convince American children that they should strive harder in mathematics if their parents maintain low standards and express high satisfaction with their children's progress. Moreover, the ability of teachers to provide effective instruction in mathematics may be diminished when mathematics is a topic for which they express little fondness and profess modest skill.

### References

- Eccles, J. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* (pp. 75–146). San Francisco: W. H. Freeman.
- Garden, R. A. (1987). The second IEA mathematics study. *Comparative Education Review*, 31, 47–68.
- Holloway, S. D., & Hess, R. D. (1985). Mothers' and teachers' attributions about children's mathematics performance. In I. E. Sigel (Ed.), *Parental belief systems: The psychological consequences for children* (pp. 177–199). Hillsdale, NJ: Erlbaum.
- Husen, T. (Ed.). (1967). *International study of achievement in mathematics: A comparison of twelve countries*. New York: Wiley.
- Kessen, W. (Ed.). (1976). *Childhood in China*. New Haven, CT: Yale University Press.
- Lee, S. Y., Ichikawa, V., & Stevenson, H. W. (1987). Beliefs and achievement in mathematics and reading: A cross-national study of Chinese, Japanese, and American children and their mothers. In D. Kleiber & M. Maehr (Eds.), *Advances in achievement and motivation: Enhancing motivation* (pp. 149–179). Greenwich, CT: JAI.
- Maccoby, E. E., & Jacklin, C. N. (1974). *The psychology of sex differences*. Stanford, CA: Stanford University Press.
- Parsons, J. E., Kaczala, C. M., & Meece, J. L. (1982). Socialization of achievement attitudes and beliefs: Classroom influences. *Child Development*, 53, 322–339.
- Stevenson, H. W., Chen, C., & Uttal, D. H. (in press). Beliefs and achievement: A study of black, white, and Hispanic children. *Child Development*.
- Stevenson, H. W., Lee, S. Y., & Stigler, J. W. (1986). Mathematics achievement of Chinese, Japanese, and American children. *Science*, 231, 693–699.
- Stevenson, H. W., Stigler, J. W., Lucker, G. W., Lee, S. Y., Hsu, C. C., & Kitamura, S. (1987). Classroom behavior and achievement of Japanese, Chinese, and American children. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 3, pp. 153–204). Hillsdale, NJ: Erlbaum.
- Stigler, J. W., Lee, S. Y., & Stevenson, H. W. (in press). Mathematical knowledge of Japanese, Chinese, and American children. *Monographs of the National Council of Teachers of Mathematics*.
- World Bank. (1985). *China: Long-term development issues and options, Annex 1*. Washington, DC: World Bank.