Low and High Mathematics Achievement in Japanese, Chinese, and American Elementary-School Children

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This study investigated factors associated with low and high levels of achievement in mathematics. Chinese, Japanese, and American first- and fifth-grade children who received scores in the top or bottom deciles of a mathematics test were given tests of intellectual ability and reading achievement, and the children and their mothers were interviewed. There were large overall differences in the mean level of mathematics achievement among the three locations. High mathematics achievers in all three locations received higher average scores on the intellectual ability tests than did the average mathematics achievers who in turn received higher scores than low-achievers. In all three locations, mothers' ratings of their children's intellectual abilities and of their own abilities in mathematics varied directly with the children's level of achievement in mathematics. Taken together, the results indicate that factors associated with levels of achievement in mathematics operate in a similar fashion across three cultures that differ greatly in their children's level of mathematics achievement.

Cross-national studies of children's school achievement have recently received a great deal of attention, primarily because of the poor performance of American children (see, for example, Comber & Keeves, 1973; McKnight et al., 1987; Stevenson, Lee, & Stigler, 1986). The average scores obtained by American children, especially in mathematics and science, are consistently below those obtained by children from many other countries. This finding has prompted calls for educational reform and for further research on factors associated with the relatively poor performance of American children (see U.S. Department of Education, 1987).

Until now, most international comparisons have focused solely on the assessment of performance and the investigation of differences in curricula. Children's scholastic achievement, however, is affected by numerous factors that exist outside of school. Differences in achievement might reflect differences in general intellectual ability as well as differences in cultural values about education and methods for influencing children's development and scholastic performance. That differences in mathematics performance emerge as early as kindergarten (Stevenson et al. 1986) provides further evidence that factors outside of school play an important role in determining the overall differences in achievement.

The research presented here is part of a continuing series of studies investigating the influence of intellectual, scholastic, and cultural factors on the academic performance of Japanese, Chinese, and American elementary-school children. This study focuses on the characteristics of children who receive exceptionally low or exceptionally high scores on a test of mathematics achievement. Isolating factors that differentiate these children from their peers who receive average scores on these tests and comparing these factors across three cultures may provide insight into critical variables related to low or high levels of children's performance in mathematics.

We assessed several factors not related directly to school activities that have been shown to be related to children's level of achievement in the United States. The first was intellectual ability. Previous research (Stevenson et al., 1985) has shown that intellectual ability differences do not explain the superior performance of Japanese or Chinese children. In the present study we sought to determine whether low and high levels of intellectual ability differentiate level of mathematics achievement among Japanese and Chinese students in the same way that they differentiate levels of achievement in the United States. We also assessed factors related to home life that have been shown to influence the scholastic performance of American children. These include the years of education of the children's mothers and fathers, information about how the children spend their time outside of school, and parents' beliefs about their children's intellectual abilities and personal characteristics.

Because this report used data from a larger investigation, an unusually large amount of information about the children and their families was available. Children's intellectual abilities were assessed using a battery of tests, and interviews with the children provided information regarding their attitudes. Demographic data and information about mothers' beliefs were obtained in extensive interviews with the children's mothers. Together, the tests and interviews provided a rich source of information about factors potentially associated with mathematics achievement. Finding that similar factors differentiate high-achievers and low-achievers within three cultures where levels of achievement differ so greatly would be strong evidence for the generality of those factors.

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Method

Subjects

The research was conducted in the Minneapolis metropolitan area, in Taipei, Taiwan, and in Sendai, Japan. These cities were selected to be as comparable as possible in socioeconomic and cultural status within each location. Ten schools within each city were selected to represent the population of the city in terms of socioeconomic status and geographic region. Six girls and 6 boys were selected at random from each of two first-grade and two fifth-grade classrooms that had been selected randomly in each of the 10 schools. The subjects for the present study were selected from these 240 first-graders and 240 fifth-graders in each location. Children classified as mentally retarded or emotionally disturbed by educators or psychologists were not included in these samples. Less than 2.5% of the children were so excluded.

The subjects for this study were selected on the basis of scores on a mathematics test that was based on the mathematics curricula of the schools in all three locations. Children whose scores were in the lowest decile within their country and grade were classified as low-achievers, and those whose scores were in the highest decile were classified as high-achievers. Thus, 24 low- and 24 high-achievers were selected from the first and fifth grades in each country. Low- and high-achievers were then matched with average performers of the same sex, age, and, wherever possible, classroom. Students whose scores fell within plus or minus one-half of a standard deviation from the mean for their country and grade were considered to be average performers. These constraints made it necessary to form two separate groups of average-achievers at each grade: one matched with low-achievers and one matched with high-achievers. It was necessary in a few cases to select an average-achieving child from another classroom in the same school.

Constructing the Mathematics Test

Constructing culturally appropriate materials has been a frequent problem in cross-cultural research. Although translated versions of standardized group mathematics tests exist, we believed a new test was necessary. Because the test was to be a measure of achievement, we thought it was important to ensure that the test reflected the material that actually appeared in the curriculum in each location. Because analyses of the mathematics curricula were not available, we decided to undertake a detailed analysis of textbooks from each location. We chose the series used in mathematics classes in Sendai, in Taipei, and the most popular series used in the Minneapolis metropolitan area. The mathematics test was based directly on the results of these analyses. The 70 items of the test were similar to those that appeared in the textbooks, but the specific items were not ones that the children had encountered in school. The reliability of the test was high; Cronbach alphas computed separately for each grade and city ranged from .93 to .95. A sample of the items from the test is shown in Figure 1. (See Stigler, Lee, Luckey, & Stevenson, 1982, for additional information about the construction and content of the mathematics test.)

Reading and Intellectual Ability

Children also were given a test of reading achievement to assess whether the differences in mathematics scores were accompanied by parallel differences in reading scores. This test was based on the reading curricula used in the three countries and has been described elsewhere (Stevenson et al., 1982). The test yielded separate scores for vocabulary and comprehension.

Intellectual abilities were assessed using a battery of 10 tests that we constructed especially for the study. The tests were similar to those found in standard intelligence batteries and were ones that were presumed to be related to children’s scholastic achievement. We constructed our own tests to avoid the cultural bias often found in trans-legged versions of standard intelligence batteries. The following is a brief description of the tests (further information can be found in Stevenson et al., 1985):

Coding. Children were required to learn a simple code that related abstract symbols to numerals.

Spatial relations. For each item, the child was asked to choose one of four geometric shapes that would form a square when combined with a target shape.

Perceptual speed. The child’s task was to match a target with one of four choices within a time limit. First-grade items were line drawings of common objects and simple shapes; fifth-grade items were more complex line drawings.

Auditory memory. The child was asked to repeat rhythmic patterns tapped out by the examiner. There were long and short intervals between taps in patterns such as short, long, long.

Memory for words. This test assessed children’s ability to repeat a series of words. The words were concrete nouns for first-graders and abstract words for fifth-graders.

Memory for numbers. This was a standard digit-span test.

\[
50 + 20 = \quad 662 \quad 583
\]

\[
8 - 6 + 7 = \quad \text{How many blocks are there in all?}
\]

Mrs. Jones divided 9 cookies among her 3 children. She gave the same number of cookies to each child. How many cookies did each child get?

\[
19 + 25 = \quad \quad 4 \quad \quad 4 \quad \quad \quad \quad \quad \quad -36
\]

Figure 1. Items from a page of the mathematics test (third-grade level).
**Verbal memory.** Children were told a story and then asked questions about its content.

**Vocabulary.** Children were asked to define words.

**General information.** The test contained questions about common knowledge, such as “How many legs does a dog have?” and “Why do blankets keep us warm?”

**Following instructions.** Children were required either to identify or to draw spatial patterns on the basis of verbal instructions.

Reliabilities for each of these tests were computed separately by grade in each location for the entire sample of 240 children. Values obtained for coding, spatial relations, perceptual speed, auditory memory, vocabulary, and general information ranged from .73 to .98, with a median value of .86. Two tests, verbal memory and verbal-spatial representation, were less reliable, with a median reliability for the former of .60 and for the latter of .77. The small number of items in serial memory for words and serial memory for numbers precluded computation of the reliability statistic.

### Mother Interview

An interview was developed that contained questions appropriate for mothers in the three locations. Suggestions for questions to be included were provided by researchers from all three locations, and the interview was constructed simultaneously in all three languages to ensure comparability. Questions covered a broad range of areas including the mother’s evaluations of her child’s abilities and of her own abilities, her child’s current and earlier experiences at home and at school, efforts to teach the child at home, and her assessments of the child’s experiences in school.

### Child Interview

A short interview was conducted with each child. Three questions are considered here: “How much do you like math?”, “How much do you like reading?”, and “How much do you like homework?”. First-grade children indicated their responses by using a 5-point “smile scale,” ranging from a broadly smiling face that indicated that they liked math very much, for example, to a deeply frowning face that indicated they did not like math at all. Fifth-graders responded to written statements rather than to the faces.

### Administration of the Tests

The reading test was administered approximately 4 months after the opening of the school year. The mathematics and intellectual ability tests and the interview with the children were administered approximately 2 months later. All tests were given to one child at a time by a well-trained examiner. Interviews with the mothers were begun 6 months after the opening of the school year.

### Results

#### Characteristics of the Samples

**Number of boys and girls.** The samples of both low- and high-achievers contained approximately equal numbers of boys and girls; there were no statistically significant sex differences in the composition of these groups. Table 1 shows the number of boys in each group.

**Classroom distribution.** If all low- or high-scoring children had come from only a few of the 20 classrooms at each grade in each location, our findings might be attributable to the effects of a few teachers or to ability grouping. This was not the case. Low-achievers came from at least 10 classrooms in each location at the first-grade level and from at least 14 classrooms at the fifth-grade level. High-achievers came from at least 13 first-grade classrooms and from at least 12 fifth-grade classrooms in each location.

There were interesting differences between locations in the distribution of low- and high-achievers among the classrooms. This distribution tended to be most restricted in the United States and broadest in Japan. Only 4 of the 20 American first-grade and 7 of the fifth-grade classrooms had at least 1 low- and 1 high-achiever. In contrast, 14 of the 20 Japanese first-grade classrooms and 12 of the 20 fifth-grade classrooms had both low- and high-achievers. Seven Chinese classrooms at both first- and fifth-grade had both a low- and high-achiever. Thus, it was more likely that both high and low achievers would be found in Japanese classrooms than in those in Taiwan or in the United States.

#### Major Analyses

Three-way analyses of variance were conducted for each of the dependent variables (achievement tests, intellectual ability tests, and responses in the interviews). The independent variables were location, sex, and achievement group (either low/average or high/average). Because the focus of this report is on differences and similarities across locations in factors related to low or high mathematics achievement, main effects for location are not emphasized. Of special interest are possible interactions between achievement level (low versus average or high versus average) and location, because the presence of significant interactions would indicate that the relations between achievement level and related factors were not consistent across the three cultures.

**Mathematics achievement.** The mean scores for each comparison group (low/average and high/average) are shown in Figure 2 for first- and fifth-graders. (Scores of the two average-achieving groups have been combined in the graphs.) The figure indicates that low and high achievement in mathematics must be defined relative to location. Although the differences between the performance of low-, average-, and high-achievers are very similar in the three locations, the absolute levels of performance are higher in Japan and Taiwan than in the United States. At both extremes of the distribution, the Chinese and Japanese children outperformed their American counterparts. The differences were all significant, $F(5, 138) > 12.47, p < .05$, except in the comparison of Chinese and American low-achievers. There were no interactions between location and levels of achievement, nor were there significant main effects or interactions associated with the sex of the child.

**Reading achievement.** Achievement in mathematics was not an isolated phenomenon. At both grades, low-achievers in
First-grade high mathematics achievers scored higher than their average-achieving peers on all other intellectual ability tests except auditory memory and memory for words, $F(1, 121-132) > 4.30, ps < .05$. Fifth-grade high-achievers scored higher than the matched group on all other tests except perceptual speed, $F(1, 131-132) > 9.18, ps < .01$. Three significant interactions between location and mathematics achievement level were found, but these were not especially revealing. Auditory memory was the only task for which there were significant interactions for both low- and high-achievers. Even for this task, however, the pattern of the interactions was not consistent.

Our next step was to determine if any of the intellectual ability tests were particularly effective in discriminating between low- and average-achieving children or between high- and average-achieving children in the three locations. Stepwise multiple discriminant function analyses were conducted separately for both the low versus average and high versus average groups for each grade in each location. Each of the cognitive tests was included as a possible discriminator, and the significance level cutoff for inclusion in the model was set at less than .05. A summary of the results of this analysis is shown in Table 2. Two conclusions can be drawn from these analyses. First, some tests, such as following instructions and verbal memory, are important discriminators of performance levels in all locations. Second, there does not appear to be a set of abilities that is unique to low or high levels of achievement in a single location.

In order to assess the predictive accuracy of the discriminant functions, a jackknife classification procedure was used (Lachenbruch & Mickey, 1968). For the low versus average analyses, the percentage of cases classified correctly as low-achievers in each grade and location stratum ranged from 56.5% to 81.7% ($Mdn = 70.8\%$); the number of cases classified correctly as average-achievers ranged from 75.0% to 91.7% ($Mdn = 83.3\%$). For the high versus average comparisons, the number of cases classified correctly as high-achievers ranged from 68.4% to 87.0% ($Mdn = 70.8\%$); the number of cases classified correctly as average-achievers ranged from 62.5% to 87.5% ($Mdn = 79.2\%$).

### Table 2

Intellectual Tests That Discriminate Mathematics Achievement Groups

<table>
<thead>
<tr>
<th>Country</th>
<th>Grade 1</th>
<th>Grade 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low-average comparisons</td>
<td>High-average comparisons</td>
</tr>
<tr>
<td>United States</td>
<td>Follow instructions</td>
<td>Spatial relations</td>
</tr>
<tr>
<td></td>
<td>Auditory memory</td>
<td>Follow instructions</td>
</tr>
<tr>
<td>Taiwan</td>
<td>Follow instructions</td>
<td>Auditory memory</td>
</tr>
<tr>
<td></td>
<td>General information</td>
<td>General information</td>
</tr>
<tr>
<td>Japan</td>
<td>Follow instructions</td>
<td>Auditory memory</td>
</tr>
<tr>
<td></td>
<td>General information</td>
<td></td>
</tr>
</tbody>
</table>

All tests except for memory for numbers proved to be effective in differentiating various groups. Low mathematics achievers received lower scores on all other tests than their average-achieving peers in both the first and the fifth grades, $F(1, 110-132) > 8.77, ps < .01$. Intellectual ability tests. We next sought to examine the relation between intellectual ability and level of mathematics achievement. Although intellectual ability cannot explain the differences between the three locations in level of mathematics achievement (see Stevenson et al., 1985), intellectual ability is strongly associated with level of mathematics achievement within each location. In all locations, low mathematics performance was associated with lower intellectual ability, and high mathematics performance was associated with higher intellectual ability.
Parental factors. The second group of factors that we assessed were those associated with parents. Although there were large mean differences between locations for many variables, the relationships between the variables and level of mathematics achievement were similar in the three locations.

Education. The first variable that we considered was parents' education. Figure 3 shows the average number of years of education for mothers and fathers of low-, average-, and high-achievers in the three locations. The relation between parents' education and children's level of mathematics achievement varied according to grade, sex of parent, and comparison group, but these relations were similar in the three locations. There were large differences across locations in years of parental education. For example, only 6% of the Minneapolis parents, but 24% of the Japanese parents and 61% of the Chinese parents, had less than a high-school education. Thus, differences in parents' education are not an explanation for the differences between cities in level of mathematics achievement. It is evident in Figure 3, however, that the relation between parental education and children's level of mathematics achievement was similar in the three cities.

Fathers of low-achieving fifth-graders had received significantly fewer years of education than the fathers of the children in the matched group, $F(1, 123) = 8.12, p < .01$. The educational levels did not differ between mothers of low- and average-achieving first- and fifth-graders. Mothers and fathers of high-achieving fifth-graders had attended school longer than mothers and fathers of average-achieving children, $F(1, 122-124) > 7.60, ps < .01$.

Mothers' perceptions of mathematics ability. Mothers were asked to rate on a scale from 1 to 9 how their children's mathematics ability compared with that of other children of the same age. The relation between level of mathematics achievement and mothers' ratings was similar within the three locations, despite the cross-national differences in the mean ratings. Low-achievers were given lower average ratings than were average-achievers, and average-achievers were given lower ratings than high-achievers, $F(1, 121-129) > 21.27, ps < .001$.

Mothers then were asked whether their children ever had any problems in arithmetic. American mothers tended to underestimate the seriousness of their children's problems. Despite the fact that the low-achievers were in the bottom 10% of their classes in arithmetic, only 1 American mother of a low-achieving first-grader said that her child had a problem in arithmetic. Ten mothers of low-achieving American fifth-graders said their children had problems. In general, Chinese and Japanese mothers were more likely to suggest that their children had problems in arithmetic. Among mothers of low-achieving children, 15 Chinese and 7 Japanese mothers stated that their first-grader had problems in arithmetic, and 15 Chinese and 18 Japanese mothers said their low-achieving fifth-grader had problems with arithmetic.

Mothers who stated that their children had a problem were asked to describe the problem. American mothers were less
likely than Chinese or Japanese mothers to describe the aspects of mathematics where their children had encountered problems. The most common explanation given by American mothers involved some type of psychologically related difficulty, such as low intelligence or inability to pay attention. Japanese and Chinese mothers, on the other hand, were more likely to attribute problems to a lack of specific skills in or knowledge of mathematics. For example, their most common explanation for first-grade difficulties was that the child did not know the addition or subtraction tables.

** Mothers' perceptions of children's abilities in other areas. ** Mothers were asked to rate their children's ability to learn new things, express themselves verbally, pay attention, use time effectively, and their children's intellectual ability, memory, and motivation to do well in school. American mothers gave their children higher ratings on many of the scales than did the Japanese or Chinese mothers, but again the relation between level of mathematics achievement and mothers' ratings was similar in the three locations.

Ratings for all variables except verbal expression and paying attention differed significantly between the first-grade low and average groups and high and average groups, $F(1, 121-122) > 4.397, ps < .05$. In fifth grade, the low-achievers were given lower ratings on all scales except using time effectively, $F(1, 122-124) > 7.222, ps < .01, F(1, 127-129) > 8.29, ps < .01$. Mothers of high-achieving fifth-graders rated their children higher on all scales, $F(1, 123-125) > 4.77, p < .05$. Only one interaction between location and level of mathematics achievement was significant: that obtained at fifth grade for mothers' ratings of the children's ability to use time effectively, $F(2, 122) = 5.140, p < .01$. Generally, mothers' ratings of other personal characteristics, such as persistence, curiosity, obedience, creativity, restlessness, and shyness were not related to children's achievement in mathematics. However, mothers of high-achieving first-graders gave higher ratings to their child's positive personal characteristics than did mothers of the matched group, $F(1, 127) = 7.91, p < .01$.

** Mothers' self-ratings. ** Mothers were asked to think of the time when they were in elementary school and to rate themselves compared with the other children in their grade. Ratings were made of the same abilities and characteristics on which they had rated their children. Mothers of both first- and fifth-grade low-achievers rated their own mathematics ability significantly lower than did mothers of average-achievers, $F(1, 111) = 8.01, p < .01$. Mothers of fifth-grade low-achievers also rated themselves lower on reading ability, general academic performance, memory, and ability to learn new things, $F(1, 113-114) > 4.56, ps < .05$.

Fewer differences were found for ratings of mothers of high-achievers. Mothers of high-achieving first-graders rated themselves higher than did mothers of average-achieving first-graders for verbal ability, reading ability, and achievement motivation, $F(1, 123-124) > 4.084, ps < .05$, but the ratings made by mothers of fifth-grade average- and high-achievers did not differ significantly. There were no significant interactions involving location and children's level of achievement.
Mothers' satisfaction and expectations for the future. Mothers' satisfaction with their child's overall school performance, their evaluation of their child's potential to do well in school, and their expectations for how far their child would go in school were related to the children's level of achievement in mathematics. As shown in Figure 4, American mothers were much more satisfied with their children's performance than were the mothers in the other two cultures. However, the relation between mothers' level of satisfaction and children's mathematics achievement was similar in the three cultures. At both grades, mothers of low-achievers were less satisfied, $F(1, 118-119) > 7.22, ps < .01$, and mothers of high-achievers were more satisfied, $F(1, 132) = 4.62, ps < .05$, than were mothers of average-achievers. The only significant interaction between location and level of mathematics achievement was for the low/average comparisons of mothers of low-achieving first-graders, $F(2, 119) = 3.50, p < .05$.

Mothers of low-achievers also said that their children would complete less schooling than did the mothers of average-achievers, $F(1, 115-119) > 9.61, ps < .01$, and mothers of fifth-grade low-achievers said that their children had less potential to do well in school. Mothers of high-achieving children in both grades believed that their children would complete more years of school than did mothers of children in the matched group and that their children had more potential to do well in school, $F(1, 123-127) > 6.04, ps < .05$.

Child Interview

When low-achievers were asked about how well they liked arithmetic, their answers were less favorable than were those of average-achievers. $F(1, 132) = 9.79, ps < .01$. This effect was found at both the first- and the fifth-grade levels (see Figure 5). For high-achievers, the differences were not consistent. First-grade, but not fifth-grade, high-achievers indicated that they liked arithmetic more than their average-scoring counterparts, $F(1, 132) = 9.09, p < .01$. The responses of low-, average-, and
high-achievers did not differ for the questions "How much do you like reading?" and "How much do you like television?".

Discussion

The results provide strong evidence for the generality of factors associated with low and high levels of achievement in mathematics. Although there were many differences in Taiwan, Japan, and the United States in the average levels of the variables investigated, there were very few significant interactions involving location and level of mathematics achievement. The factors also appeared to operate in a similar fashion for boys and for girls; there were few significant interactions involving the sex of the child. Taken together, the results are relevant both to understanding the generality of factors associated with poor and excellent levels of performance in mathematics in different cultures and to explorations of the bases of the large overall differences among the cultures in level of mathematics achievement.

The results of the tests of intellectual ability were straightforward. When considered in relation to previous analyses (Stevenson et al., 1985), our results indicate that intellectual ability is strongly related to level of mathematics ability within all three locations, but not associated with between-location variation. Attempts to demonstrate that the high achievement of Asian children is an indication of their superior intellectual abilities (e.g. Lynn, 1982) appear to have been motivated by a common but erroneous assumption that factors associated with within-group variation are probably associated with between-group variation (see Scarr, 1987).

In general, the relation between mothers' expectations and beliefs and children's level of mathematics achievement was similar in the three locations. Mothers of low mathematics achievers gave their children low ratings on almost all intellectual traits, and mothers of high-achievers gave their children high ratings. Similarly, low-achieving children said they liked mathematics less than average-achieving children. The generality of these factors is interesting in light of the large variation in the mean level of many of the factors.

Unlike the analyses of intellectual abilities, our results revealed potentially important differences between locations in the average level of ratings. For example, American mothers gave their children higher ratings on intellectual, motivational, and academic characteristics than did Japanese or Chinese mothers, and American mothers were more satisfied with their children's performance. In fact, the levels of satisfaction of mothers of low-achieving American children were nearly as high as those of mothers of high-achieving Japanese children. Similarly, American mothers were less likely to acknowledge the presence of their children's problems in mathematics than were Chinese and Japanese mothers. Such factors may play an important role in determining children's general level of academic motivation. American mothers' high evaluations of their children's abilities and high satisfaction with their children's ac-

complishments may reduce the motivation of American children to strive harder in their study of mathematics.

The results also suggest that differences in experiences at school must play a large role in determining the large differences in achievement levels in the three locations. Chinese children's performance is particularly interesting in this regard. The achievement level of low-achieving Chinese and low-achieving American children was similar in first grade, but Chinese low-achievers performed much better than American low-achievers in fifth grade. Chinese schooling, therefore, may be more successful than American schooling in realizing the achievement potential of children at all levels of intellectual ability and socioeconomic status.

These results are supportive of efforts to study children in other cultures as one means of seeking ways to improve our understanding of the bases of the performance of American children in mathematics. Because characteristics of high- and low-achievers were not unique to a single culture, the results provide evidence of the generality of factors associated with level of mathematics achievement.

References


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