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# Mathematics Achievement of Chinese, Japanese, and American Children

HAROLD W. STEVENSON, SHIN-YING LEE, JAMES W. STIGLER

**American kindergarten children lag behind Japanese children in their understanding of mathematics; by fifth grade they are surpassed by both Japanese and Chinese children. Efforts to isolate bases for these differences involved testing children on other achievement and cognitive tasks, interviewing mothers and teachers, and observing children in their classrooms. Cognitive abilities of children in the three countries are similar, but large differences exist in the children's life in school, the attitudes and beliefs of their mothers, and the involvement of both parents and children in schoolwork.**

POOR SCHOLASTIC PERFORMANCE BY AMERICAN CHILDREN has focused attention on education, especially in mathematics and science. Funds for research on how to improve teaching have been allocated and commissions formed, such as a National Research Council committee exploring a research agenda for precollege education in mathematics, science, and technology. Recommendations to be made by this committee and others that have preceded it concentrate on the nation's secondary schools. The wisdom of this emphasis is questionable. Results emerging from a large cross-national study of elementary school children suggest that Americans should not focus solely on improving the performance of high school students. The problems arise earlier. American children appear to lag behind children in other countries in reading and mathematics as early as kindergarten and continue to perform less effectively during the years of elementary school. When differences in achievement arise so early in the child's formal education, more must be involved than inadequate formal educational practices. Improving secondary education is an important goal, but concentrating remedial efforts on secondary schools may come too late in the academic careers of most students to be effective.

Our research deals with the scholastic achievement of American, Chinese, and Japanese children in kindergarten and grades 1 and 5. Children were given achievement tests and a battery of cognitive tasks. The children and their mothers and teachers were interviewed, and observations were made in the children's classrooms. These procedures have yielded an enormous array of information (*1–5*). In this article, we focus on the discussion of achievement in mathematics and factors that may contribute to the poor performance of American children in that area.

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## Achievement Tests

Comparative studies of children's scholastic achievement are hindered by the lack of culturally fair, interesting, and psychometrically sound tests and research materials. It was necessary to construct material in order to test children in Taiwan, Japan, and the United States for our study. A team of bilingual researchers from each culture constructed tests and other research instruments with the aim of eliminating as much as possible any cultural bias (*1, 2*).

Mathematics tests were based on the content of the textbooks used in the three cities in which we conducted our research. Analyses were made of each mathematical construct and operation and of the time that it was introduced in the textbook. The test for kindergarten children contained items assessing basic concepts and operations included in the curricula from kindergarten through the third grade. The mathematics test constructed for elementary school children contained 70 items derived from concepts and skills appearing in the mathematics curricula through grade 6. Some items required only computation, and others required application of mathematical principles to story problems.

Reading tests were based on analyses of the words, grammatical structures, and story content of the readers used in the three cities. There were separate tests for kindergarten and for elementary school children. The kindergarten test tapped letter and word recognition and contained comprehension items of gradually increasing difficulty. The reading test for grades 1 through 6 consisted of three parts: sight reading of vocabulary, reading of meaningful text, and comprehension of text.

Tests were constructed for administration to one child at a time. The tests were not timed. The testing procedure required that the child continue in the test to the point where over a quarter of the items at a grade level were failed. The mathematics tests and the kindergarten reading test were given 6 months after the beginning

of the school year. Reading tests were given 2 months earlier in grades 1 and 5. Carefully written instructions in all three languages and personal contact with the supervisors of the examiners helped produce testing procedures that were as comparable as possible in the three cities (*7*).

## Selecting the Children

Children in only one city in each country were studied. In the United States, we selected children in the Minneapolis metropolitan area. Several factors led to this choice, the most important being that the residents of this area tend to come from native-born, English-speaking, economically sound families. Few are from a minority background. These factors, we assumed, would provide an advantageous cultural, economic, and linguistic environment for learning in school. If problems were found in Minneapolis, we assumed they would be compounded in other American cities where a greater proportion of the children speak English as a second language, come from economically disadvantaged homes, and have parents whose cultural backgrounds diverge from the typically middle-class milieu to which American elementary school curricula generally are addressed.

The Japanese city that we chose as being most comparable to Minneapolis was Sendai, which is located in the Tohoku region several hundred miles northeast of Tokyo. It, too, is a large, economically successful city, with little heavy industry and with an economic and cultural status in Japan similar to that of Minneapolis in the United States. Taipei was the Chinese city in which it was most feasible for us to conduct our research, in terms of language, size, colleagues, and other factors.

Ten schools in each city were selected to provide a representative sample of the city's elementary schools (*6*). Because we wanted to test children shortly after they entered elementary school and also near the end of their elementary education, we randomly chose two first-grade and two fifth-grade classrooms in each school. The age of school entrance is the same in all three countries and elementary school attendance is mandatory. From each classroom we randomly chose six boys and six girls. This procedure resulted in a sample of 240 first-graders and 240 fifth-graders from each city.

Kindergartens in Taiwan and Japan are mainly privately owned and attendance is not compulsory. Nevertheless, more than 98 percent of the 5-year-olds in Sendai and over 80 percent of the 5-year-olds in Taipei attend kindergarten for at least a full year. All Minneapolis children attend kindergarten. Children in the study came from 24 kindergarten classes in each city. In order to ensure that the samples of kindergarten and elementary school children in Taipei and Sendai would be comparable, the kindergartens chosen were among those attended by children from the ten elementary schools. Six boys and six girls were randomly chosen from each classroom, yielding a sample in each city of 288 children for study. A representative sample of 24 kindergarten classrooms was selected in the Minneapolis metropolitan area.

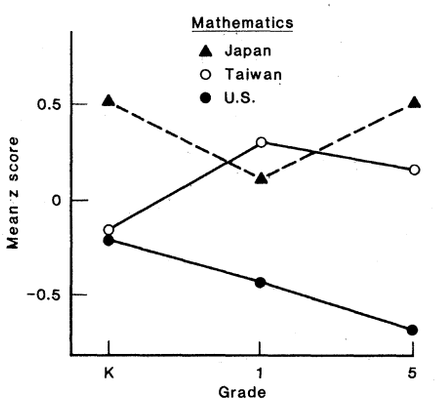


Fig. 1. Children's performance on the mathematics test. (Standard deviations for kindergarten, grade 1, and grade 5 were as follows: Japan, 0.77, 0.93, and 1.00; Taiwan, 1.10, 0.98, and 0.76; United States, 0.83, 0.96, and 0.83.)

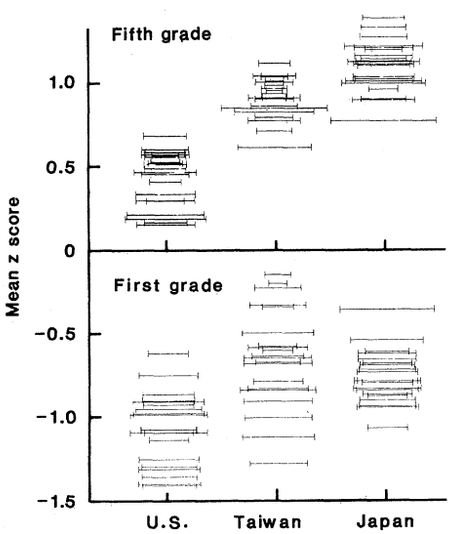


Fig. 2. Performance in each classroom on the mathematics test.

## Mathematics Achievement

The American children's scores were lower than those of the Japanese children in kindergarten and at grades 1 and 5, and lower than those of the Chinese children's at grades 1 and 5 (Table 1). Average scores for boys and girls did not show statistically significant differences from each other at any of the three grade levels.

Figure 1 shows graphically the result of transforming each child's score into a $z$ score, which represents the departure in standard deviation units from the mean of a distribution derived from the scores of the children in all three cities at each grade level. Scores were then recombined according to country, and the mean score of children in each country was determined. Consistently superior performance of the Japanese children and rapid improvement in the scores of the Chinese children from kindergarten through fifth grade are evident. Scores of the American children display a consistent decline compared to those of the Chinese and Japanese children.

Another way of considering the data is in terms of the performance in each classroom. Data for the first- and fifth-grade children are presented in Fig. 2. Each line represents one classroom. The height of the line represents the average score for the 12 children tested in each of the 20 classrooms in each city, and the width of the line represents the range of scores within each classroom. The $z$ scores were obtained in a manner similar to that just described, except that the raw scores for both first- and fifth-graders were combined into a single distribution from which the $z$ score for each child was computed. The $z$ scores were then compiled for each classroom.

A high degree of overlap appears in the distributions of scores for the first-grade classrooms in the three cities. At the fifth-grade level there is a clear separation. The highest average score of an American fifth-grade classroom was below that of the Japanese fifth-grade classroom with the lowest average score. In addition, only one Chinese classroom showed an average score lower than the American classroom with the highest average score. Equally remarkable is the fact that the lowest average score for a fifth-grade American classroom was only slightly higher than the average score for the best first-grade Chinese classroom.

Viewed in still another way, the data indicate that among the 100 top scorers on the mathematics test at grade 1, there were only 15 American children. At grade 5, only one American child appeared among the 100 top scorers from the total sample of approximately 720 children. On the other hand, among the children receiving the 100 lowest scores at each grade, there were 58 American children at grade 1 and 67 at grade 5.

The low level of performance of American children was not due to a few exceptionally low-scoring classrooms nor to a particular area of weakness. They were as ineffective in calculating as in solving word problems. The search for an adequate explanation of these findings will be a long one, for many factors are involved in producing such large differences in performance. Some of the most obvious alternatives are discussed below, including the children's cognitive abilities and several factors related to school and home.

## Reading Achievement and Cognitive Abilities

A look at results for the reading test helps clarify whether low levels of achievement generally characterized the academic performance of American children. Although reading scores show statistically significant differences among the three cities, the differences were less extreme than those in mathematics. Chinese children had the highest average scores and Japanese children the lowest. Average scores for the American children consistently were in the middle. Data presented in Fig. 3 from the vocabulary portion of the reading test illustrate these results.

Solving mathematics problems is one aspect of cognitive functioning. Perhaps differences in mathematics scores reflect differences in general intelligence among children in the three cultures. Although Lynn (*8*) has suggested that Japanese children display general cognitive superiority to American children, his study had numerous methodological problems, such as selective sampling of children in Japan (*9*). The cognitive tasks constructed especially for evaluating the intellectual functioning of Japanese, Chinese, and American children in this study offer data related to these cross-national comparisons. The tasks included performance tasks, such as perceptual speed, coding, and spatial abilities, and verbal tasks, such as vocabulary, verbal memory, and general information.

We found no evidence to support Lynn's suggestion; American children did not receive lower average scores than the Chinese and Japanese children during kindergarten or at grades 1 or 5. In fact, American children obtained the highest scores on many of the tasks during kindergarten and first grade. By the fifth grade there was no overall difference in the total scores received by the children in the three cities (*3*).

## Life in School

Our information about the children's experiences in school is based on extensive observations made in each elementary school classroom. Each classroom was visited according to a schedule in which the time of observation was randomized during a period of several weeks. The observer's attention was focused on the children for some of the observations and on the teacher for others. Behavior was coded according to an objective coding system (*4*). The number of hours of observation was 1353 in Minneapolis, 1600 in Taipei, and 1200 in Sendai.

Learning depends, in part, on the amount of time spent in practicing the material to be learned. We therefore looked at the percentage of time devoted to academic activities, and especially to mathematics. American first-graders were engaged in academic activities a smaller percentage of time than the Chinese and Japanese children: 69.8 percent for the American children, 85.1 percent for the Chinese children, and 79.2 percent for the Japanese children.

By fifth grade, differences between the American and the Chinese and the Japanese children were greater than at the lower grades. American children spent 64.5 percent of their classroom time involved in academic activities. Chinese children spent 91.5 percent, and Japanese children, 87.4 percent. Assuming that our observations provide a representative picture of what went on in Minneapolis fifth-grade classrooms, we estimate that 19.6 hours per week (64.5 percent of the 30.4 hours the American children spend in

Table 1. Mean scores (±SD) on the mathematics tests for kindergarten (K) and grades 1 and 5. Scheffé method contrasts: United States < Japan at kindergarten, grade 1, and grade 5 ($P < 0.001$); United States < Taiwan at grade 1 and grade 5 ($P < 0.01$). Sample sizes for United States, Taiwan, and Japan, respectively: kindergarten, 288, 286, and 280; grade 1, 237, 241, and 240; and grade 5, 238, 241, and 239.

| Grade | United States | Taiwan | Japan |
|---|---|---|---|
| K | 37.5 ± 5.6 | 37.8 ± 7.4 | 42.2 ± 5.1 |
| 1 | 17.1 ± 5.3 | 21.2 ± 5.5 | 20.1 ± 5.2 |
| 5 | 44.4 ± 6.2 | 50.8 ± 5.7 | 53.3 ± 7.5 |

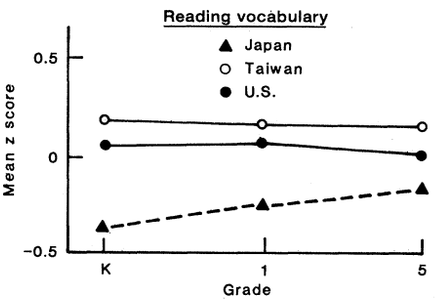


Fig. 3. Children's performance on the vocabulary portion of the reading test. (Standard deviations for kindergarten, grade 1, and grade 5 were as follows: Taiwan, 0.99, 1.06, and 0.84; United States, 0.98, 1.12, and 1.07; Japan, 0.84, 0.72, and 1.05.)

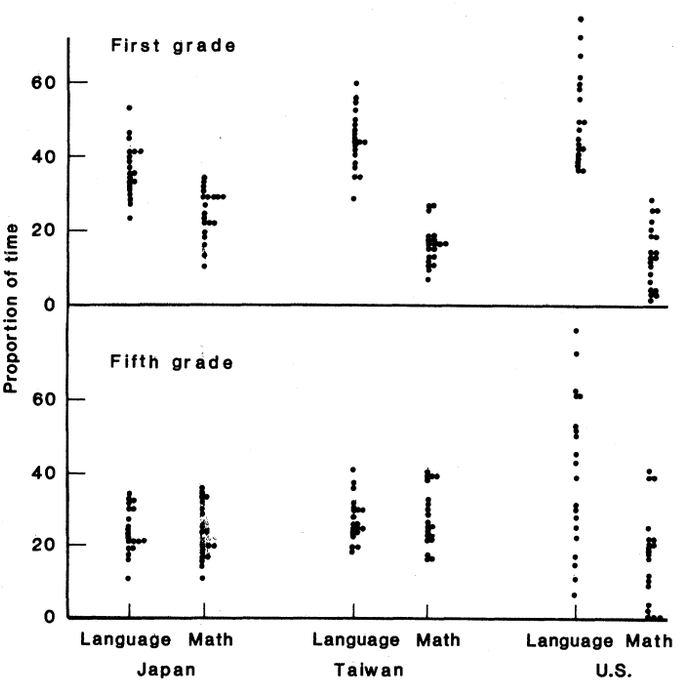


Fig. 4. Proportion of time spent in each classroom on language arts and mathematics from classroom observations.

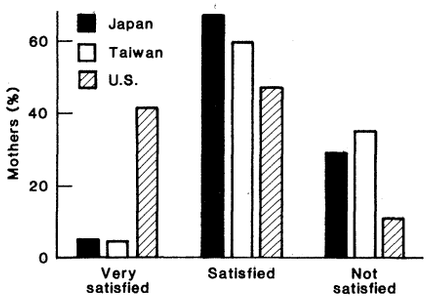


Fig. 5. Mothers' attitudes toward children's academic performance.

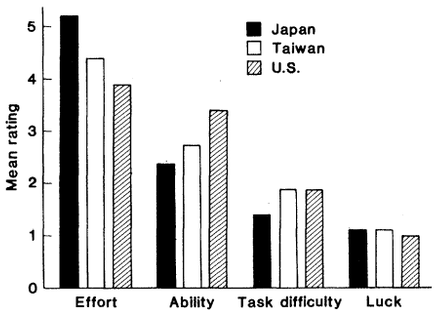


Fig. 6. Mothers' ratings of factors contributing to academic success.

school) were devoted to academic activities. This is less than half the estimate of 40.4 hours (91.5 percent of 44.1 hours that Chinese children attend school) devoted to academic activities in the fifth-grade Chinese classrooms, and not much less than half of the 32.6 hours (87.4 percent of 37.3 hours that Japanese children attend school) in the Japanese classrooms.

In both grades 1 and 5, American children spent less than 20 percent of their time on the average studying mathematics in school. This was less than the percentage for either Chinese or Japanese children. At the fifth grade, language arts (including reading) and mathematics occupied approximately equal amounts of time for the Chinese and Japanese children, but the American children spent more than twice as much time on language arts (40 percent) as on mathematics (17 percent) (Fig. 4). In some of the American classrooms, no time was devoted to work in mathematics during the approximately 40 randomly selected hours when an observer was present. The high variability among American classrooms in the time allocated to the various academic subjects can be readily explained. There are precisely defined curricula in Taiwan and Japan, and teachers are expected to adhere closely to these curricula. American teachers are allowed to organize their classrooms much more according to their own desires; hence, there is greater variability among classrooms.

The leader of a classroom activity in which a child was engaged could be the teacher, another adult, such as a teacher's aide, or a child. Asian and American classrooms had strikingly different patterns of leadership. Children in Taipei were led by the teacher nearly 90 percent of the time; in Sendai, more than 70 percent of the time. Children in Minneapolis, in contrast, spent less than half their time in classrooms where they were led by the teacher. Children can learn without a teacher. Nevertheless, it seems likely that they could profit from having their teacher as a leader more than half of the time.

Moreover, American teachers spent proportionally much less time imparting information (21 percent) than did the Chinese (58 percent) or Japanese (33 percent) teachers. These are sobering results. American children were in school approximately 30 hours a week. This means that they were receiving information from the teacher for approximately 6 hours a week (0.21 times 30). Computing similar estimates for Chinese and Japanese classrooms gives values of 26 hours for Chinese children and 12 hours for Japanese children. American teachers actually spent somewhat more time giving directions than in imparting information (26 percent compared to 21 percent).

There were other interesting differences in the ways children spent their time in school. For example, we sometimes found that a child who was known to be at school was not present in the classroom. The child could be at the school office, on an errand for the teacher, in another classroom, or in the library. This occurred 18.4 percent of the time that an American fifth-grader was to be observed, but less than 0.2 percent of the time in Taipei and Sendai classrooms.

The comparatively low levels of achievement of the American children in mathematics appear to be attributable in part to the fact that they are not receiving amounts of instruction comparable to those received by children in Taiwan and Japan. These cross-national differences become even more profound when they are extended over the school year. Chinese and Japanese children spend half a day at school on Saturdays and have fewer holidays than do American children. As a result, American children attend school an average of 178 days a year; Chinese and Japanese children attend school for 240 days. In addition, Japanese fifth-graders were estimated by their mothers to spend an average of 1 hour more each day, and the Chinese children, 2 hours more each day at school than the American children. Taken together, these data point to enormous differences in the amounts of schooling young children receive in the three countries.

## Homework

Learning occurs at home as well as at school. But our data indicate that neither American parents nor teachers of elementary school children tend to believe that homework is of much value. As a consequence, American children spend much less time on homework than do Japanese children, and both groups spend vastly less time on homework than do Chinese children. American mothers estimated that on weekdays their first-graders spent an average of 14 minutes a day on homework; the daily average for Chinese first-graders was 77 minutes, and for Japanese, 37 minutes. For fifth-graders, the estimate for the American children was 46 minutes a day; for the Chinese and Japanese fifth-graders the estimates were 114 and 57 minutes a day, respectively. On weekends, American children studied even less: an estimated 7 minutes on Saturday and 11 minutes on Sunday. The corresponding values for Chinese children were 83 and 73 minutes, and for the Japanese children, 37 and 29 minutes—and this was in addition to the half day in school on Saturday. American children also were given less help when they were doing their homework, according to their mothers' estimates. Someone, usually the mother, assisted the fifth-grade children with their homework an average of 14 minutes a day. The Chinese children were assisted by some family member an average of 27 minutes a day, and the Japanese children, 19 minutes a day.

Parental concern about a child's schoolwork was evident in another simple index, the possession of a desk. Only 63 percent of the American fifth-graders, but 98 percent of the Japanese and 95 percent of the Chinese fifth-graders had desks. When the Chinese and Japanese children were not occupied with homework, they were given other opportunities to practice by solving the problems appearing in the workbooks purchased for them by their parents. Only 28 percent of the parents of American fifth-graders, but 58 percent of the Japanese and 56 percent of the Chinese parents bought their children workbooks in mathematics. The discrepancy

was even more pronounced in the purchase of workbooks in science, which were purchased by only 1 percent of the American parents, but by 29 percent of the Japanese and 51 percent of the Chinese parents.

How did children in the three cities react to doing homework? Taipei children said they liked homework; children in Minneapolis said they did not like homework; and the attitudes of the Sendai children were somewhere in between. When asked to choose among an array of five frowning, neutral, or smiling faces to express their attitudes about homework, more than 60 percent of the Chinese fifth-graders chose a smiling face, more than 60 percent of the Japanese children chose a smiling or neutral face, and 60 percent of the American children chose a frowning face. Although 30 percent of the American children chose a smiling face at first grade, the percentage was half that among fifth-graders.

One indication of what teachers thought about homework appeared in their ratings of the value of homework and 15 other activities directed at helping children do well in school. Ratings given to the value of homework by American teachers placed it 15th among 16 items—lowest except for physical punishment. Chinese and Japanese teachers were much more positive; the average rating given by Chinese teachers on a 9-point scale was 7.3; by Japanese teachers, 5.8; and by American teachers, 4.4.

The small amounts of homework assigned to American children were not in conflict with the mothers' beliefs about how much schoolwork their child should be assigned. Among American mothers, 69 percent said that the amount of homework was "just right." Nor were the Chinese and Japanese mothers dissatisfied with the large amounts of homework assigned to their children; 82 percent of the Chinese mothers and 67 percent of the Japanese mothers thought the amount was "just right."

## Mothers' Evaluations

When asked to rate their child's achievement in mathematics, American mothers gave their children favorable evaluations. Ratings were made on nine-point scales, each anchored by five defining statements, ranging from "much below average" to "much above average." Although mothers were asked to compare their child with "other children of his or her age," the mean rating made by the American mothers for their child's ability in mathematics was 5.9, higher than the average rating 5.2 of the Chinese mothers and similar to the average of 5.8 of the Japanese mothers.

Mothers were also asked to rate children on several cognitive abilities, each defined by several words or a short phrase. Great care was taken to select words and phrases that express the same nuances of meaning in the three languages. American mothers consistently gave their children the highest average ratings and Japanese mothers gave their children the lowest. For example, on ratings of a child's intellectual ability, the average rating given by American mothers was 6.3, much above the 5.0 that would indicate an average level of ability. The average rating given by the Japanese mothers was 5.5, and by the Chinese mothers, 6.1.

Despite the positive bias of the American mothers, the rank order of their ratings was in line with the children's performance. The correlation between the mothers' ratings of the children's abilities in mathematics and the fifth-graders' scores on the mathematics test was 0.50 in Minneapolis, 0.37 in Taipei, and 0.54 in Sendai. The high ratings made by American mothers must be attributed to an excessively positive attitude, rather than to a failure to perceive a child's status in relation to other children. Conversely, the low ratings of Japanese mothers appear to reflect an effort to be more realistic in their evaluations.

The optimism of the American mothers was reflected in other ways. They were pleased with the job the schools were doing in educating their children: 91 percent judged that the school was doing an "excellent" or "good" job. Only 42 percent of the Chinese mothers and 39 percent of the Japanese mothers were this positive. Instead, the majority of the Chinese and Japanese mothers considered that the schools were doing a "fair" job.

The high esteem the American mothers had for their children's cognitive abilities extended to their satisfaction with their children's current academic performance. More than 40 percent of the American mothers described themselves as being "very satisfied" (Fig. 5). Fewer than 6 percent of the Chinese and Japanese mothers were this positive.

When asked if there were things about their children's education that could be improved, 45 percent of the American mothers of fifth-graders who suggested improvements could be made emphasized improvement in academic subjects. The subject that they thought should get more emphasis was reading (48 percent of the suggestions). Mathematics and science were seldom mentioned (<6 percent of the suggestions). The subjects mentioned most frequently by the Japanese mothers were reading and mathematics. Chinese mothers, on the other hand, believed that more emphasis should be given to music, art, and gym.

The positive attitudes of the mothers did not mean that American children liked school. In rating how well they liked school, 52 percent of the American children, compared to 86 percent of the Chinese fifth-graders, chose a smiling face. (The question was not asked in Japan.)

Critics of Chinese and Japanese education often suggest that the high demands placed on children result in ambivalence or dislike of school. This does not seem to be the case in elementary schools. It is the American children who regard elementary school less positively. Expressing a dislike for school may be a socially acceptable reaction among American school children. Even young children in Taiwan and Japan are aware of the fact that education is highly prized in the Chinese and Japanese cultures. The emphasis on scholastic achievement may lead to the intense competition that is often said to characterize secondary schools in Taiwan and Japan, but negative consequences were not evident during the elementary school years. In fact, the children in all three cities appeared to be cheerful, enthusiastic, vigorous, and responsive. Although some of these characteristics may be more vividly expressed in classrooms in Minneapolis, they are readily apparent to the observer who follows Chinese and Japanese children through their school day.

## Parental Beliefs

Experiences that parents provide their children may be strongly influenced by their general beliefs about the components of success. For example, parents who emphasize ability as the most important requisite for success may be less disposed to stress the need to work hard than would parents who believe success is largely dependent on effort.

In exploring cultural differences in beliefs about the relative importance of factors leading to success in school, we asked the mothers to rank effort, natural ability, difficulty of the schoolwork, and luck or chance by importance in determining a child's performance in school. They were then asked to assign a total of ten points to the four factors. Japanese mothers assigned the most points to effort, and American mothers gave the largest number of points to ability (Fig. 6). The willingness of Japanese and Chinese children to work so hard in school may be due, in part, to the stronger belief on the part of their mothers in the value of hard work.

## Outside Assistance

It has been suggested that the scholastic performance of young Chinese and Japanese children is due in part to outside tutoring. Articles about the *juku*, the cram schools of Japan, and the *buxiban*, the after-hours schools in Taiwan, have appeared in American newspapers. These seem to be phenomena associated with later years of schooling, for few mothers said that their elementary school children attended such classes. Children in all three of the cities that we studied were enrolled in after-school lessons or classes, but these were not necessarily ones that would help the children with their schoolwork. American children most frequently took lessons in various types of sports. Among Chinese children, the most popular lessons were in sports and calligraphy, and among Japanese children, the most popular lessons were in art and calligraphy. The percentage of children taking lessons in mathematics was higher in Sendai (7 percent) than in Taipei (2 percent), but not higher than the percentage in Minneapolis (8 percent).

## The Teachers

The number of hours teachers spent with the children each week did not show statistically significant differences among the three countries, despite the fact that the hours were spread out over 5.5 days a week in Taiwan and Japan, and only 5 days in the United States. American and Japanese teachers estimated that they spent 28 hours a week teaching, and the Chinese teachers, 30 hours. The amount of time spent at school did differ greatly—an average of 51 hours for the Japanese teachers, 47 hours for the Chinese teachers, and 42 hours for the American teachers. This means that American teachers have little time when they are at school for activities other than those where they are directly responsible for the children in their classroom, a factor that may help explain the complaints of American teachers that they are overworked.

American teachers frequently said that if they could shed some of their nonacademic functions, they could spend more of their time actually teaching. A large amount of classroom time is spent in unproductive activities that can be attributed, in part, to the American teachers being asked to take on too many functions other than teaching, including the roles of counselor, family therapist, and surrogate parent. This diversion of energy is perhaps the most common problem of American elementary school teachers, and is one that was seldom mentioned by the teachers in Taipei and Sendai. Such problems are not due to there being a greater number of children in the American classrooms, for the average number of children in the Minneapolis elementary school classrooms was 21, whereas it was 47 in Taipei and 39 in Sendai.

Whether increased time for teaching would result in improved instruction in mathematics and science is questionable. When asked whether there were ways in which they would change the curriculum if they were free to do so, nearly a quarter of the American teachers had no suggestions. The two most frequent suggestions related to academic subjects involved placing more emphasis on "basics" (13 percent) and increasing the time available for reading, spelling, and language instruction (18 percent). Only one American teacher expressed a desire to spend more time on mathematics.

## Current Data

The data for the elementary school children were collected in 1980, and for the kindergarten children in 1984. A follow-up study also was undertaken in 1984 of children who had been included in our first-grade sample, but now were in the fifth grade. Little change occurred in the children's performance during the four years. The mean score for the American children in 1984 on the mathematics test was 44.9, a score nearly identical to the average of 44.5 obtained by the fifth-graders 4 years earlier. The Japanese children remained ahead, with a mean score of 51.

Differences in the attitudes of mothers in the three countries were as strong as they had been 4 years earlier. In analyses of the 1984 data that have been completed, we have found, for example, that mothers of American fifth-graders were even more satisfied, and Chinese and Japanese mothers were just as dissatisfied with their child's performance in 1984 as mothers were in 1980. Nearly 60 percent of the American mothers, compared to 40 percent 4 years earlier, were "very satisfied" with their child's current academic performance. Fewer than 10 percent of the Chinese and Japanese mothers were "very satisfied."

## Conclusions

Impetus for change often comes from dissatisfaction with the present state of affairs. Most American mothers interviewed in this study did not appear to be dissatisfied with their children's schools, and seem unlikely, therefore, to become advocates for reform. Moreover, the children, faced with parents who generally are satisfied and approving of what happens in school, must see little need to spend more time and effort on their schoolwork. The poor performance of American children in mathematics thus reflects a general failure to perceive that American elementary school children are performing ineffectively and that there is a need for improvement and change if the United States is to remain competitive with other countries in areas such as technology and science which require a solid foundation in mathematical skills.

The lack of time spent teaching mathematics may be a reflection of the view of American parents and teachers that education in elementary school is synonymous with learning to read. Large amounts of time are devoted to reading instruction, and if changes were to be made in the curriculum, both parents and teachers agreed that even greater proportions of time should be devoted to reading. Mathematics and science play a small role in Americans' conception of elementary education.

American mothers have unrealistically favorable evaluations of their children and what they are accomplishing in school. This optimism may lead to a sense of well-being but is unwarranted in the context of cross-national comparisons of children's scholastic achievement. When we look only within the United States, we may find cause to deplore the poor performance only of certain subgroups of our population. When we broaden our perspective to include children from other countries, we have cause for concern. Although a small proportion of American children perform superbly, the large majority appear to be falling behind their peers in other countries.

The data we have presented are from a single set of studies, conducted in particular locales and with particular methods. Nevertheless, the findings are directly in line with those from other cross-national studies of achievement in mathematics and science involving older children and adolescents (*10–12*). Preliminary results from the Second International Mathematics Study, for example, indicate that among eighth-graders from 20 countries, Japanese children received the highest scores in arithmetic, algebra, geometry, statistics, and measurement. The average scores of the American children on these tests ranged from 8th to 18th position. The poor performance of American children that begins in kindergarten is maintained through the later grades.

Regardless of the funds that may be allocated to the development and application of new methods of teaching, it seems obvious that children's success in mathematics and other subjects will depend on greater awareness and an increased willingness by American parents to be of direct assistance to their children. Schools may be improved, but the task of helping children reach higher levels of achievement cannot be accomplished without more cooperation and communication between the school and the home. Further, without greater acknowledgement of the importance of the elementary school years to children's education in mathematics and science, legislation to improve instruction in secondary schools may result in little more than exercises in remediation for most children.


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7. Statistical analyses of the achievement tests indicated good reliability. Tests of the reliability of the mathematics test yielded values that ranged from 0.92 to 0.95 when the Cronbach $\alpha$ statistic was computed separately by grade and country. The coefficients of concordance for the three parts of the reading test ranged from 0.91 to 0.94 when computed separately for each country. Results for standardized tests of mathematics and reading were not obtained for purposes of comparison with our tests. The standardized achievement tests, if available, were not comparable among the three countries; the results often were not current; and they were group tests, rather than individually administered tests such as those used in this study.
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13. This article reports results from a collaborative study undertaken with S. Kitamura, S. Kimura, and T. Kato of Tohoku Fukushi College in Sendai, Japan, and C. C. Hsu of National Taiwan University in Taipei. Supported by NIMH grants MH 33259 and MH 30567.


## Research Articles

# Separation of DNA Binding from the Transcription-Activating Function of a Eukaryotic Regulatory Protein


LIAM KEEGAN, GRACE GILL, MARK PTASHNE



**The yeast GAL4 protein (881 amino acids) binds to specific DNA sites upstream of target genes and activates transcription. Derivatives of this protein bearing as few as 74 amino terminal residues bind to these sites but fail to activate transcription. When appropriately positioned in front of a gene these derivatives act as repressors. These and related findings support the idea that GAL4 activates transcription by touching other DNA-bound proteins.**


TRANSCRIPTION OF MANY EUKARYOTIC GENES DEPENDS ON DNA sites located far from the gene (*1*). For example, midway between the divergently transcribed *GAL1* and *GAL10* genes of yeast, about 250 bp from each, is a region called the *GAL* upstream activation site ($UAS_G$). The $UAS_G$ is essential for the transcriptional activation of both genes by GAL4 protein (GAL4) (*2–8*). If the $UAS_G$ is placed as far as 600 bp from the transcription start site of a *GAL* gene, or of a heterologous gene, GAL4 activates transcription of that gene (*9*).

On the basis of chemical probe experiments on intact cells, Giniger *et al.* (*10*) have argued that GAL4 binds to four related 17-bp sequences in $UAS_G$. One synthetic 17-bp sequence is sufficient to mediate significant GAL4-dependent activation of downstream genes. This sequence is a near-consensus of the natural sites, and is called (for convenience) the 17mer (*11*). Bram and Kornberg (*12*) have shown that GAL4 binds to specific sites in $UAS_G$.

How does a DNA-bound protein such as GAL4 activate transcription at a site several hundred base pairs away? Specifically, is the binding of GAL4 sufficient for upstream activation? Here we show (i) that GAL4 binds to the $UAS_G$ and to the 17mer in vitro, and (ii)


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