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America's Math Problems

A look at the sources of Asian students' superior performance provides insight into improving the accomplishments of our own students.

Photographs by Harold Stevenson

A study of mathematical achievement conducted in Sendai, Japan, showed that by the age of five, Japanese children already exceed their American counterparts in knowledge of basic concepts and skills.

America's math problems are serious. They begin when our children are very young, persist throughout primary and secondary school, and are not limited to any particular aspect of mathematics. Just how bad is the situation?

American and Asian Achievement Compared

Clearly, our students are not doing as well in mathematics as their peers in other countries. A recent report from the Second International Mathematics Study (McKnight et al. 1987) offers information about the performance of junior high and high school students. On tests given to students from 20 countries, American eighth-graders ranked tenth in arithmetic, twelfth in algebra, and sixteenth in geometry. Twelfth-grade American students fared just as badly. When compared to students from 14 other countries, they were second from the bottom in their scores in algebra, and in geometry they were in the lowest quarter of performance.

Less well known but just as alarming is the situation with younger children. America's math problems begin early. By the age of five, Japanese children already exceed their American counterparts in knowledge of basic concepts and skills. That the difference widens after formal instruction begins in elementary school is evident from a recent study my colleagues and I conducted with a representative sample of approximately 3,000 first-graders and 3,500 fifth-graders, equally divided among four cities: the Japanese city of Sendai, the Chinese cities of Beijing and Taipei, and Chicago (Stevenson et al. in preparation).

Among the students in the top five percent at grade one across all four cities, there were only three American children. If children in each city had performed equally well, we would have expected over 40. The top five percent of fifth-graders contained only two American children. Among the worst students in mathematics—those in the bottom five percent—there were 163 American children at grade one and 181 at grade five. In fact, at grade five only 13 of the children in the bottom five percent were *not* American.

Another way of looking at the results is to examine the school means. Of the 20 Chicago schools we visited, only one school's fifth-graders obtained an average score as high as the lowest average score for the 31 schools in Beijing, Sendai, and Taipei. In a fifth-grade geometry test, there was no overlap between the means of the Asian and the American schools. These data parallel those of a previous study of mathematical achievement we conducted in Taipei, Sendai, and the Minneapolis metropolitan area (Stevenson et al. 1986).

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Americans often charge that Asian children learn by rote. The test of mathematical operations we constructed actually capitalizes on this type of learning. In fact, though, contemporary Asian teachers use many different instructional approaches. Moreover, the group mathematics test was supplemented by a battery of a dozen other tests of skill and knowledge in mathematics; these tests were given individually to samples of children from each of the schools. In areas where rote learning could not be a factor, such as in answering questions involving word problems, mathematical reasoning, mathematical concepts, and spatial relations, American children did no better.

American Complacency vs. Asian Diligence

In addition to testing children, we interviewed them, their mothers, and their teachers, and observed in their classrooms. (Unfortunately, interviews with fathers were not feasible.) The contrasts posed by these comparative data provide insight into the bases of American children's poor performance.

One of our first discoveries was that most Americans do not believe we have a problem related to mathematics. Both the students and their parents believe the children are doing well in the subject. For example, American children are more optimistic about their future performance in mathematics than are Chinese and Japanese children. When we asked American first-graders how well they believed they would do in mathematics next year, 75 percent said they would be among the best students. Only 37 percent of the Sendai and 50 percent of the Taipei first-graders were this confident. (Beijing data have not yet been analyzed.) Similarly, 58 percent of the American fifth-graders expected to be above average or among the best students in mathematics in high school,

percentages that again were much higher than those of their Japanese and Chinese peers, among whom 26 percent and 29 percent, respectively, anticipated this degree of success.

The average American mother believes that her child is above average in mathematics achievement. Using a 9-point rating scale, on which 5 is considered "average," mothers of Minneapolis first- and fifth-graders gave their children a mean rating of 6. Moreover, when asked to rate academic potential, only 7 percent of the mothers considered their child's academic potential as average or below.

This optimistic attitude was conveyed to American children, who reported that their parents and their teachers were satisfied with their performance. Eighty-seven percent of American fifth-graders thought their parents were "happy" or "very happy" with their math performance. The percentages of ratings at these levels for the Japanese and Chinese children were 52 percent and 38 percent, respectively.

Similarly, 83 percent of American children thought their teachers were "happy" or "very happy" with how well they were doing in mathematics—compared to 22 percent of Japanese and 37 percent of Chinese children. It will be difficult to convince Americans that their children should work harder in mathematics when both parents and children are satisfied with their current performance.

The difficulties are compounded by the fact that Americans generally do not consider mathematics as important as reading in elementary school. According to our classroom observations, American teachers spend more class time on reading (language arts) than on mathematics at both first and fifth grades. Chinese and Japanese teachers, however, divide their time

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more evenly between these two subjects. Incidentally, our Japanese colleagues startled us by saying that they believe American children are doing remarkably well in mathematics. When pressed for an explanation, they replied that in a culture where so little time is spent teaching children mathematics and where mathematics is given so little emphasis, American students demonstrate commendable progress.

Despite the greater amount of time devoted to language arts in the U.S. as compared to the Asian countries, American mothers most frequently said that reading should be given more emphasis in elementary school. Japanese mothers were nearly three times as likely as American mothers to mention a need for greater emphasis on mathematics. Chinese mothers thought more time should be devoted to music, art, and gym. Our country's problems in mathematics may stem in part, therefore, from a belief that mathematics is not a topic of special importance.

Educational Practices Reflect Cultural Philosophies

How much time is spent teaching mathematics in the classroom? Based on our 1,200 to 1,600 hours of observation in the first- and fifth-grade classrooms of Minneapolis, Sendai, and Taipei, we estimate that American first-grade teachers average about 11 hours a week on language arts and nearly 3 hours a week on mathematics. Corresponding values for the Japanese classrooms are nearly 9 and 6 hours a week, and for the Chinese classrooms, 10 and 4 hours a week. At fifth grade, the disparity in time spent on mathematics among the different cities is even greater. American teachers spend an average of 3 hours a week on mathematics; Japanese teachers, 8 hours a week; and Chinese teachers, 12 hours a week.

Even within the time devoted to mathematics classes, direct instruction is markedly less in American than in Chinese and Japanese classrooms. American children spend nearly 20 percent of their classroom time in first grade and 15 percent in fifth grade engaged in irrelevant activities (e.g., being out of their seats, talking to classmates, or otherwise behaving inappropriately). Chinese and Japanese children are much less likely to be off-task. Further, American children spend more time doing seat work with no direct supervision by the teacher, carrying out errands and other activities outside the classroom, and making transitions from one activity to another.

Foreign visitors often note two features of Asian classrooms: the close attention of the children to what is

being taught and the spirited instructional modes of the teachers. These are a result, in part, of the organization of the school day. Mathematics is typically taught in the morning, when children are least fatigued, and the morning is punctuated with frequent recesses. After every 40- or 50-minute class, the children are allowed to expend their energy in vigorous play. These frequent changes in pace may contribute to Asian children's ability to concentrate closely when the class is in session. Teachers, too, are able to devote themselves intensely to teaching, for they are required to be in charge of the classroom for fewer hours than are American teachers. Although the time they are at school is comparable to that of American teachers, Asian teachers have more free time to prepare lessons, work with individual children, and devote to other activities related to their teaching.

Japanese and Chinese elementary schools are in session for more hours each week and for more weeks during the year than are American schools. Some American policymakers have seized upon this fact as providing a solution to America's problems in education. More time in school, they suggest, will result in improved learning. At least for elementary schools, this is unlikely to prove true. Children will not necessarily learn more simply by increasing their exposure to materials. More essential changes are needed.

Mathematics instruction averages six hours per week in Japanese first-grade classrooms, compared to three hours a week in American classrooms, and is typically taught in the morning when children are least fatigued.

The slow bird, says a Chinese proverb, needs to start out early. Asian children are shaped by the cultural value that potential for change lies within the individual, innate differences in ability are deemphasized

The vitality and effectiveness that characterize Asian elementary schools must become more common to the elementary schools of the United States. Therefore, we need to understand the *sources* of the diligence of Asian students and the dedication of their parents and teachers. These lie, we believe, in fundamental Asian attitudes about human behavior. Asian philosophy has long espoused a belief that human beings are like clay, shaped by the events of daily life. Differences in innate ability are deemphasized, and the potential for change throughout life is believed to lie within the individual. As a result, teachers and parents believe that any child is capable of learning. Children may have different learning rates, for which compensations may need to be made, but all children without mental defects are expected to be able to understand the materials presented in the elementary school curriculum.

This set of beliefs, accompanied by the Asians' long-held respect for learning, is a powerful basis for devoting a great deal of energy to promoting children's academic achievement. Asian parents teach their children early that the route to success lies in hard work. Teachers recognize individual differences among children but demand that all children work hard. If a child's rate of learning is slower than that of other children, it means only that the child must study even harder. The slow bird, says a Chinese proverb, needs to start out early. Children rapidly absorb these cultural values.

Compared to the Asians we interviewed, Americans placed more emphasis on differences in innate ability as the basis for variations in achievement. American children, for example, were much more likely than Chinese or Japanese children to agree with the statement, "The tests you take can show how much or how little natural ability you have." Conversely, American children were least likely to agree that "everybody in your class has the same amount of ability in math."

These beliefs are in line with those of their mothers. American mothers did not agree that people have the same amount of ability in mathematics. When asked about the role of effort, Chinese and Japanese mothers were more likely than American mothers to believe that any student can be good at mathematics if he or she works hard enough. American mothers also expressed stronger beliefs than Chinese and Japanese mothers that their children were born with their math abilities.

Educational policies reflect the differences between the Asian and American views. American public schools, we often say, seek to provide the best education possible for each individual child. To do this, we make early efforts to evaluate differences in ability so that

children can be placed in educational tracks that will be most beneficial to them. Within Asian schools tracking is unknown. An educational administrator summarized the Japanese position as follows: "The purpose of education in Japan is to reduce individual differences." Presumably, this does not mean lowering standards but rather raising the level of performance of all children.

The consequences of these differences in beliefs are amplified by the lower expectations American parents hold for their children's achievement. Not only do they fail to stress the importance of working hard, but the standards they impose upon their children are less demanding. For example, when asked how satisfied they were with their child's achievement in school, 53 percent of the American mothers, but fewer than 10 percent of the Chinese and Japanese mothers, indicated that they were "very satisfied."

That lower expectations are also held by teachers and others responsible for American mathematics curriculums as represented in textbooks is evident from our extensive analysis of Asian and American textbooks. A guiding principle underlying the presentation of material in American textbooks is the importance of repetition and review at each grade level. Many American teachers told us that they do not believe it necessary to cover all the material because they know students will encounter it again in a later grade. The Asian textbooks, in contrast, seem to be developed on the assumption that new knowledge should build on previous learning: if a concept or skill is taught well the first time, there is no reason to repeat the discussion about it later.

Concepts are also introduced earlier in the Japanese than in the American textbooks. Of 497 concepts and skills common to elementary textbooks of both countries, 30 percent are introduced earlier in the Japanese texts. Even when concepts are introduced earlier in the American texts (in 19 percent of the cases), they are not as sophisticated as those in the Japanese textbooks. For example, probability is introduced in the second semester of fourth grade in American textbooks; Japanese students do not encounter the concept until sixth grade, but they are expected immediately to make inferences on the basis of probabilistic statements.

Even the children seemed aware of these differences in the difficulty of the mathematics curriculums. American children did not think mathematics was difficult; in fact, 58 percent at grade one and 40 percent at grade five thought mathematics was "easy" or "very easy." Judgments by the Japanese children on the other hand were more sober: only 32 percent at grade one and 30 percent at grade five evaluated mathematics so casually. The opinions of the Taipei children changed greatly between grades one and five; there was a decrease from 64 percent to 22 percent in the number of children who thought mathematics was "easy" or "very easy."

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Expect Little, Get Little

To appreciate the severity of America's education problems, we must compare what children in other countries learn during their elementary school years. Although I have stressed mathematics in this discussion, other comparative studies reveal deficiencies of American children in science and reading as well (Comber and Keeves 1973, Lee et al. 1986). Complacency about egregiously inferior levels of accomplishment is likely to erode American status both at home and abroad.

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To participate fully in a society increasingly dependent upon advanced technology, our citizens must understand the basic principles of mathematics and science. How can we mobilize ourselves to make the changes in American education that will enable us to perform effectively in worldwide competition and for our own self-improvement?

Superficial modifications of our educational practices will not be sufficient; the base of our problems lies in beliefs about such fundamental factors as the importance of mathematics and science, teaching procedures, and the usefulness of effort. The kinds of cultural changes necessary will not be easy. And they are unlikely to occur at all until Americans realize the extent of their children's deficiencies.□

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References

Comber, L. C., and J. Keeves. *Science Achievement in Nineteen Countries.* New York: Wiley, 1973.

Lee, S. Y., J. W. Stigler, and H. W. Stevenson. "Beginning Reading in Chinese and English." In *Learning to Read: Cognitive Universals and Cultural Constraints,* edited by A. Siegel and B. Foorman. Hillside, N.J.: Erlbaum, 1986.

McKnight, C. C., F. J. Crosswhite, J. A. Dossey, E. Kifer, J. O. Swafford, K. J. Travers, and T. J. Cooney. *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective.* Champaign, Ill.: Stipes, 1987. Available for $8.00 plus $1.00 postage from Stipes Publishing Co., 10–12 Chester St., Champaign, IL 61820.

Stevenson, H. W., S. Y. Lee, and J. W. Stigler. "Mathematics Achievement of Chinese, Japanese, and American Children." *Science* 231 (1986): 693–699.

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