The Mathematics Education of Students in Japan: A Comparison with United States Mathematics Programs

Sarah Mastrull
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Bristol Township School District
MIC 8 Training

As a mathematics teacher in a secondary school, I wanted to find out why Japanese students score so high against other students in standardized tests, and why Japanese schools turn out such able workers. I chose to research the education of Japanese students in mathematics and compare the education they receive to the education my school's students receive through the *Mathematics in Context* program.

The Japanese government does not lavish money on education. In fact, Japanese schools are unadorned, functional places. The Japanese achieve their various functions in society and their respective status levels through formal classroom achievements, followed by rigorous qualifying examinations for most of the positions of greatest prestige (Reischauer, 1988). The importance of school education is stressed in the home during the preschool years, which helps form the attitude that hard work will lead to progress in learning. Japanese parents, especially mothers, take an active role in their children's education. Because so few Japanese women have jobs once they marry, their primary measure of success becomes the education of their children (Sudo, 1989). In his 1989 research, Sudo surveyed both American and Asian mothers. When asked what score they would be satisfied with on a math exam, American mothers said 72, or a C, while Asian mothers said 92 - an A.

Japanese students are not smarter than students are elsewhere, though they undoubtedly work harder. Americans attend school an average of 178 days per year, vs. 200 days in Japan (Rapoport, 1989). Japanese students go to school Monday through Saturday, with Saturday a half day. The average class size is forty, and they stay in the same room all day while different teachers come in. The curriculum and the

textbooks are nationally standardized by the Ministry of Education, so that every student studies the same materials (Sudo, 1989).

The Japanese assume that learning is the product of effort, perseverance, and self-discipline rather than of ability. The schools have no ability grouping in the elementary and junior high schools and virtually no individualized classroom instruction (Becker, et al., 1990). All children go through junior high school, and 94% of Japanese youth attend high school. Close to a third of the graduates continue on to higher education (Reischauer, 1988). Those who graduate have the equivalent of three to four years more schooling than U.S. graduates do. Japanese graduates have all studied calculus, physics, and chemistry. Fewer than half of U.S. students take a year of physics and chemistry, and only 6 percent study calculus (Sudo, 1989).

The Japanese mathematics curriculum differs from the U.S. curriculum in many ways. Topics from the elementary grades are not repeated. Algebra and geometry are a major focus of the junior high curriculum. Much of the U.S. ninth and tenth grade mathematics is learned in the eighth and ninth grades in Japan, including probability and statistics and some solid geometry. The pace at which mathematics is taught to all Japanese students at the junior high school level is roughly equivalent to the advanced track in a good suburban school system in the United States (Becker, et al., 1990).

The Third International Mathematics and Science Study - Repeat (TIMSS), conducted in 1999, studied math and science classes in thirty-eight countries. The researchers conclude that U.S. math and science curricula lack focus and coherence and, compared to other high-achieving nations, have lower expectations. The results

demonstrate that American school children are not being challenged enough. U.S. eighth graders are being taught at a seventh grade level compared to many of their international counterparts.

The 1999 TIMSS study also analyzed textbooks in use in these thirty-eight countries. Typical eighth grade mathematics textbooks in America cover more than 35 topics, compared to fewer than ten topics in both Japan. We need to concentrate on teaching each topic in a way that gives students time to struggle with the problem being addressed before being told the answer. This is the only way that they can acquire the knowledge and skills that will be useful for them later.

The TIMSS researchers videotaped numerous lessons in the United States and Japan and developed the following statistics:

- In 96% of U.S. math lessons, students practice a procedure, as compared to 46% in Japan. In only 1% of U.S. math lessons do student formulate the procedures themselves, as compared to 44% in Japan.
- 0% of the videotaped U.S. eighth grade math lessons had instances of deductive thinking, as opposed to 61% of the Japanese lessons. In the United States, lessons were interrupted 28% of the time, compared with only 2% in Japan.

This is why, out of the 38 nations studied, Japan ranked third and the United States ranked 28th in the eighth grade mathematics achievement results. The TIMSS videotape study shows that Japanese teachers, more than their American counterparts,

are using techniques that resemble what is called for in our nation's mathematics standards.

In Japan, mathematics classes are generally scheduled during the first periods of the day. In their observations of Japanese classes, Becker and his colleagues (1990) found a typical mathematics lesson to be organized as follows:

- Students' rising and bowing
- Reviewing previous day's problems or introducing a problem-solving topic
- Problem solving by students, working in pairs or small groups
- Comparing and discussing solution methods
- Teacher highlights and summarizes the major points
- Assigning homework (only two to four problems)
- Sounding of soft gong, indicating end of class
- Students rise and bow

With the exception of the rising, bowing and sounding the gong, this class structure is very similar to that of American mathematics classes using the *Mathematics in Context* program. Becker et al. (1990) observed few or no gender differences in teachers' interaction with students. They also saw no discernible differences between boys' and girls' attitudes toward learning.

At present, teaching is geared toward the system of exams, which the Japanese must take to get into high school, into a university, into graduate school, and into a good job. Entry into an elite high school puts one on track for entry into an elite university, which virtually assures students of jobs at the best companies. Students

who don't qualify for the better schools end up in technical and vocational schools (Sudo, 1990).

Sudo (1990) interviewed Naohiko Hirata, an 18-year-old native of Yokohama, Japan. Hirata began studying for his high school entrance exam in fifth grade, when he was eleven years old. " 'Some people started studying in fourth grade," he said. 'My friend was already studying four hours a day [when I started]. From the early ages, that's all you think about: Study, study, study, so you can go to good schools and go to a good company.' " (p. 13). The long hours and years of study are known *as shiken jigoku* -- examination hell.

Like American students, all applicants to four-year public universities are required to take entrance exams. The Japanese know that their performance on these exams has a very significant impact on their fate. Unlike United States SAT tests, these exams are tightly tied to what is taught in school. Since Japan has a national curriculum, every student is guaranteed the opportunity to be taught the appropriate subject matter (Wu, 1993). Those students who wish extra help or more preparation for exams can attend *juku*, or "cram school," for extra study. After school, 80 percent of Japanese students have private tutors or attend jukus at their family's expense (Sudo, 1989). Naohiko Harata, the student interviewed by Sudo (1989), describes the typical long hours devoted to studying. " 'Usually I'd go home at 3:40 p.m., get some sleep until 5, then study for two hours until supper. After supper, I'd study sometimes until 2 or 3 in the morning. When I was 15, I went to *juku* three times a week, including Saturday after a half-day at school. Then I studied eight hours a day on Sunday' " (pg. 13).

Japan is a highly developed technological society, so one would assume calculators would be in use in mathematics classrooms. In their observations, Becker et al. (1990) saw no use of calculators. They learned that (1) attitudes of parents and elementary school teachers do not yet favor their use, (2) the use of calculators is not allowed on entrance examinations for senior high school, and (3) studies are under way to assess the merits of their use in teaching methods.

Schaub and Baker (1991) conducted an empirical study on the mathematics achievement in Japanese and American middle grades. They conclude that end-of-year achievement in American classrooms is more determined by student inputs (abilities and past learning) than that in Japanese classrooms. What a class of students ends up knowing in Japan is less dependent on what they begin the year with (p. 633). They also found that American teachers prepare less, review older material, and spend more time on keeping order and doing administrative tasks during the classroom period than Japanese teachers do. Japanese teachers teach more often to the entire classroom, while American teachers tend to use instructional methods that are directed toward the individual student. Japanese teachers who reduce variation among students in a class are successful in yielding higher achievement. Teaching to the class as a whole is just one among several ways in which Japanese schooling reduces variation. Others include avoiding streaming of ability groups and the use of class activities such as preparation of school meals and maintaining school buildings (Schaub & Baker, 1991).

According to the 1999 TIMSS study, the U.S. teachers see their role as to demonstrate how to complete tasks and help students who are "stuck." In Japan,

however, the teacher's role is to choose engaging problems, manage discussion to help different methods to surface, and summarize the lesson. In Japan, students decide 40% of the time how to solve math tasks rather than using a teacher-prescribed method. In the United States, students are called upon to use their own strategy 9% of the time. The role of Japanese teachers is, in reality, the role that teachers of the *Mathematics in Context* series play in the classroom. We, as teachers of the *MIC* program, serve as facilitators rather than demonstrators of procedures.

Most American educators imagine a society in which most every individual functions actively in the economic, social, political, and spiritual aspects of his or her world. We also hope that each individual will gain through education a broad base of information and skills that can be applied to any given experience. GwenEllyn Nordquist lived in Japan for three years. In the article about her experience in Japanese society (1993), she found that Japanese education is by no means perfect. It is, first and foremost, rote memorization. The Japanese are not good at putting ideas into their own words, at taking material apart to understand its components, or putting parts together to make (or remake) the whole, or think creatively. She says that "…in their system, if something is memorized, it is learned" (p. 67).

Because the Japanese students do so well compared to United States students, the current reform of mathematics curricula is justified. Programs like *Mathematics in Context* and *Core Plus* allow teachers to be facilitators rather than declarers of formulas. We need to allow students to struggle through problems, as difficult a task as it might be, for only in working through problems will students really understand the

concept behind them. Instead of rote memorization of formulas, students need to be enabled with the knowledge and thought processes necessary to become critical thinkers. Reflecting upon what works and what doesn't, in our country and in others such as Japan, will allow is to become to better educators. Allowing children to think for themselves instead of telling them how to solve math problems will allow them to become better students. Problem solving skills learned in math class can be applied in all facets of one's life.

In conclusion, I believe that though its functions are quite different from that of the United States educational system, there is much that we can learn from the Japanese system of education. Through my research, I found some methods that I can apply to my teaching of mathematics. No one system of education is perfect. Keeping and open mind and a willingness to accept others' ideas is the key to keeping our educational system and our society functioning well.

REFERENCES

Becker, J. P., Silver, E. A., Kantowski, M. G., Travers, K. J., & Wilson, J. W. (1990). Some observations of mathematics teaching in Japanese elementary and junior high schools. Arithmetic Teacher, 38, 12-21.

Colcutt, M., Jansen, M., & Kumakura, I. (1988). Cultural atlas of Japan. New York: Facts on File.

Lynn, Richard. (1988). Educational achievement in Japan: lessons for the west. Armonk, N. Y.: M. E. Sharpe, Inc.

National Center for Educational Statistics (2001). *Third International Mathematics and Science Study - Repeat.* Washington, DC: US Department of Education. http://nces,ed,gov/TIMSS-r/index.asp.

Nordquist, GwenEllyn. (1993). Japanese education: no recipe for authentic learning. Educational Leadership, 50, 64-67.

Rapoport, Carla. (1989). A look inside a Japanese school. Fortune, 120, 155-160.

Reischauer, Edwin O. (1988). The Japanese today. Cambridge: Harvard University Press.

Schaub, M., & Baker, D. P. (1991). Solving the math problem: exploring mathematics achievement in Japanese and American middle grades. American Journal of Education, 99, 623-642.

"Solutions." Narr. Peter Jennings. ABC World News Tonight, New York, N.Y. 20 Feb. 1997.

Sudo, Phil. (1989). How Japan hits the books. Scholastic Update, 122, 11-12.

Sudo, Phil. (1989). Life after 'Exam Hell.' Scholastic Update, 122, 13.

Wu, Eileen T. (1993). Japanese university entrance examination problems in mathematics. American Federation of Teachers, Spring 1993, 25-35.

The mathematical education provided in the United States has proved to be inferior compared to that of other countries. Specifically the Japanese and other Asian educational systems produce more educated mathematics students than the United States. American children tend to score lower on standardized testing than Asian students do.Â In a comparison between typical eighth grade classes from Japan and the United States, these differences are made clear. American teachers tend to spend the first part of the period demonstrating a specific type of problem. The second portion of the class is spent applying the methods learned. The teachers assign problems for the students to try while he or she observes, helping anyone that is having trouble. International Comparisons in Mathematics Education: An Overview 633. Studies that cross national boundaries provide participating countries with a broader context within which to examine their own implicit the-ories, values and practices. As well, comparative studies provide an opportunity to examine a variety of teaching practices, curriculum goals and structures, school organisational patterns, and other arrangements for education that might not exist in a single jurisdiction.Â It examined the achievement of students from three populations at ve grade levels (9-year-olds, 13-year-olds, and students in the nal year of secondary school) in a wide range of content and performance areas, and it collected contextual information from students, teachers, and school principals.