From Formal Standards to Everyday Practice of Mathematics Learning: Illustrations from the TIMSS Case Study Project in Japan

Carol J. Kinney, Akane Zusho, Ann Arbor, MI (USA)

Abstract: This paper uses the example of six Japanese teachers and their mathematics lessons to illustrate how clear, high standards for mathematics instruction are combined with teachers’ holistic concern for students. We draw upon data from the Third International Math and Science Study Case Study Project in Japan that was designed to elucidate the context behind the high achievement of Japanese students. Using everyday examples of classroom practice, we illustrate both flexibility in teachers’ approach to teaching and adherence to Mombusho’s (Ministry of Education, Science, Sports, and Culture) Course of Study. Our purpose is to emphasize how flexibility and attention to individual needs by Japanese teachers combine with quality mathematics instruction based on the detailed Japanese curricula.

Six teachers’ characteristics and lessons (two teachers at each educational level – elementary, junior high, and high school) are described in order to show the variety of teachers who exist in Japan. These teachers use their understanding of the Course of Study and are supported by their school environment to enhance their students’ conceptual understanding of the fundamentals of mathematics. Characteristics of their teaching include: 1) involving the whole class in learning, 2) using extremely focused curriculum guidelines that expect mastery of concepts at each grade level, 3) thoroughly covering mathematics units in an organized and in-depth manner, 4) leading classes as facilitators or guides more often than as lecturers, and 5) focusing on problem solving with the primary goal of developing students’ ability to reason, especially to reason inductively. The examples in this paper show how these methods develop in individual classrooms.


ZDM-Classification: D10, D40

Japanese students continue to astound researchers and educators alike with their consistently high scores on various international assessments of mathematics achievement. Although ousted from their previous number one ranking by Singapore and Hong Kong in the Third International Mathematics and Science Study (TIMSS), Japan still presents a formidable challenge to the other industrialized nations of the world in terms of students’ performance on mathematics achievement tests. Among the 41 countries participating in the Population 2 (eighth grade) assessment of the TIMSS, Japan was ranked first in geometry; second in number sense, algebra, and measurement; third in data analysis and probability; and fourth in proportionality (Peak, 1996). Japanese fourth graders achieved at equally high levels, placing third among a total of 17 nations.

So, what explains these consistently high scores? From genetics to cultural beliefs, explanations concerning Asian mathematics superiority have been numerous and varied. However, converging evidence seems to suggest that, in part, these cross-national differences can be attributed to differences in school instruction and the quality of mathematics instruction. Gilford cited a need for small, in-depth studies that “permit cross-cultural comparisons of a myriad of causal variables not recognized in large-scale surveys” (1993, p. 22). LeTendre specifically addresses studies on Japan when he suggests that more comparative qualitative work may help “inhibit the recurrent use of stereotypes and reasoning based on stereotypes” that has burdened much of the debate about Japanese educational practices (LeTendre 1999).

The Case Study Project was an attempt to compare innumerable contextual variables across three levels of schooling in each of three countries. As such, it provides an initial foray into sorting out which differences in context may contribute to Japanese mathematics success. We suggest that clear national guidelines and supportive school environments encourage mathematics teachers to focus on teaching for conceptual understanding of fundamentals, while allowing for flexibility in approach.

The Case Study Project was included as part of TIMSS to examine daily practices within schools. It included classroom observations and interviews with teachers, students, parents, administrators, and government officials and complements and complicates the information gathered through questionnaires, test scores, and other parts of the TIMSS study. Case studies were conducted in three countries: The US, Japan, and Germany. Three locations were visited in each country: one primary site in a large city in a central region and two secondary sites located in smaller cities in different regions of each country. Three schools at each level of schooling were chosen in consultation with local education authorities in the main location and one school at each level was chosen in each
secondary location. Schools at the primary site were chosen to represent successful, average, and less successful schools in terms of scores on achievement tests and high school and college entrance examinations. Interviews and observations were extensive; for example, over 255 hours of math and science classroom observations were conducted in the three countries. In Japan, over 494 hours of interviews were conducted with 247 people.

In each country, there were four major topics of investigation – National Standards, Individual Differences, Adolescents’ Lives, and Teachers’ Lives – each studied by one researcher who spent two to three months at the major research site. In addition, other researchers conducted supplementary observations and interviews. All interviews were tape-recorded, transcribed, and translated. Extensive notes taken of observations and conversations were also entered into a shared computer data base. Carol Kinney conducted the two month investigation into Teachers’ Lives at the primary site in Japan, and the examples in this paper are drawn largely from her work.

One goal of the Case Study Project was to link everyday mathematics learning to general standards and test scores. This paper clarifies how Monbusho (Ministry of Education, Science, Sports, and Culture) guidelines help shape mathematics learning in Japan while also pointing out the anomalies and contradictions that exist in everyday life in Japanese schools. Using examples of teachers observed during the Case Study Project, this paper seeks to provide a more detailed account of a few Japanese mathematics classrooms and the daily activities of six teachers in Japan. These individuals continually interact with the structure of education in Japan. Examining how each lesson adheres to as well as diverges from a model lesson illustrates how the structure of education shapes individuals’ behavior and how individuals in turn shape that structure. This paper provides contextual information that emphasizes how a commitment to fostering conceptual understanding by mathematics teachers in Japan is situated within what teachers described as their primary concern for the overall needs of students.

The first section reviews research related to various characteristics of Japanese mathematics education. The remaining sections describe the daily activities of six Japanese teachers, two from each level of schooling.

1. Characteristics of Japanese mathematics education

1.1 The curriculum

The Japanese educational system centers on the activities of Monbusho. One of the primary responsibilities of Monbusho is the establishment of national curriculum guidelines for all subjects at all educational levels. These guidelines, also known as the Course of Study, provide specific information to teachers and textbook developers concerning course content and sequence, as well as time allotment for each subject area. The information provided in the mathematics portion of the Course of Study forms the basis of the Japanese mathematics curriculum. All instructional materials, such as student textbooks and workbooks, along with teacher manuals, are carefully reviewed at Monbusho for adherence to these standards.

The Course of Study is widely distributed in most major bookstores across Japan in the form of three booklets, one for each level of schooling. Although in outline form, the information provided in the Course of Study is fairly detailed. For the area of mathematics, specific concepts that must be mastered at each grade level are listed according to the four main mathematical strands (numbers and operations, quantity and measurement, geometrical figures, quantitative relations). For example, in terms of numbers and operations, fourth graders are expected to

a) perfect their place-value concept by learning about the one hundred millionth place (oku) and the trillionth place (cho) (the Japanese number system is based on units of 10,000, not 1,000),

b) develop their understanding of number estimation,

c) become proficient in the multiplication of integers,

d) extend their understanding as well as skill in executing division problems,

e) develop an understanding of decimals as well as fractions,

f) refine their understanding of the four basic operations of arithmetic and,

g) become able to perform addition and subtraction problems on an abacus (Monbusho, 1989).

In the second section of this paper, Mr. Nomura’s review lesson on mixed operation equations and Ms. Tanaka’s lesson on long division demonstrate how teachers pace their classes to master these concepts.

A defining characteristic of the curriculum is its emphasis on conceptual understanding of fundamental mathematical concepts. For example, the fourth grade math guidelines in the Course of Study for Elementary Schools (Monbusho 1989) do not merely state that students must learn how to divide by the end of the school year. As our lessons show, students in the fourth grade are expected to extend their understanding of the meaning of division as well as increase their skill in solving more complicated division problems, such as larger digit problems with remainders. Specifically, the guidelines state that students must learn how to perform division of two-digit integers and understand the following relationship: (Dividend) = (Divisor) × (Quotient) + (Remainder).

A closer examination of the mathematics section of the Course of Study reveals several other interesting facets of the Japanese math curriculum. First of all, instead of recycling the same concepts year after year, the curriculum is extremely focused and expects mastery of concepts at each grade level. As a result, mathematical concepts are organized within each grade level and across grades, such that new concepts build upon previously mastered material. Let us look at the elementary school guidelines for quantity and measurement as an example. The first grade objectives are remarkably simple. Rather than introduce specific terms and concepts, the only requirement put forth in the Course of Study is the development of a general sense of quantity and measurement. This is accomplished primarily by focusing on the direct comparison of objects and using real-life objects as units of measurement. Standardized units of length, such as meters, centimeters, and millimeters along with those units associated with volume