# Lessons in Perspective:

# How Culture Shapes Math Instruction in

# Japan, Germany and the United States

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# Introduction

## A Cross-Cultural Look at Math Instruction

The quality of math instruction in the United States has evolved over time into one of our great national pressure points of anxiety. As the global economy has become progressively more demanding of workers' math skills and U.S. test scores have remained mediocre in international comparisons, a series of predictable cries have gone out: What are we doing wrong? What are they doing right? And how can we catch up?

This phenomenon reached a crisis point in California with the release of the National Assessment of Educational Progress (NAEP) results, which again showed California students ranking at or near the bottom in reading and math scores when compared to other states. While a great deal of finger-pointing has ensued, so, too, has a renewed search for solutions that can enhance student achievement in California and throughout the country. One of the most innovative and potentially rewarding of these efforts is a study recently completed by Dr. James Stigler of UCLA. Undertaken as a component of the Third International Math and Science Study (TIMSS), Dr. Stigler's project surveyed math teaching techniques in three countries: Japan, Germany and the United States.

What made Dr. Stigler's study unique—and uniquely valuable—is that, rather than distributing standard survey instruments and asking teachers to conduct written self-evaluations of their methods and techniques, Dr. Stigler opted to videotape a true random sampling of math teachers in each country and have an international panel of teachers evaluate each tape based on a common range of factors. The "slice of life" approach provided a remarkably unvarnished snapshot of teaching styles and methods in the three countries involved in the study, and the carefully monitored analysis and coding by a panel including researchers from each country studied helped ensure that a wealth of useful comparative data was generated.

Dr. Stigler's study also offers a remarkably balanced and detailed look at how cultural differences affect teaching in the classroom, and particularly how American cultural norms and expectations unconsciously shape our entire approach to education. The results demonstrate that cross-cultural studies can often tell the native researcher more about his or her own system than about those of the other countries being examined, because the process of comparison often forces us to take a new look at characteristics and assumptions about our own system that we might otherwise take for granted.

## May 14, 1997 Seminar

On May 14, 1997, the California Education Policy Seminar and the California State University Institute for Education Reform assembled a group of 41 California policy-makers, administrators, educators and policy advocates in Sacramento to witness a presentation by Dr. Stigler, discuss the results of his study, and consider what we can do to improve math instruction in California's classrooms.

Dr. James Stigler, prior to authoring the study discussed in the May 14 seminar, co-authored the acclaimed study *The Learning Gap* with Harold Stevenson ("the best education book I read in my many years in the Legislature," according to Institute for Education Reform Co-Director Gary K. Hart). The book examined how elementary math was taught in five cities in Asia and the United States. Dr. Stigler is currently a Professor of Psychology at UCLA. He also served on California Superintendent of Public Instruction Delaine Eastin's Math Task Force, and taught previously at the University of Chicago.

## Presentation of Dr. James Stigler

*[NOTES: (1) Throughout this report, comments made by individuals participating in the May 14 seminar are summarized without quotation; all text contained herein should be regarded as paraphrasing and/or synthesizing what was actually said, and not as quotes attributable either to Dr. Stigler or to any other participant. (2) Dr. Stigler's presentation featured his exposition and illustrations of a great deal of information surrounding the TIMSS results, interspersed with an ongoing dialogue with the seminar's participants. This "math conversation" is presented here primarily as notes from a lecture, with segments of the dialogue included in boxes at contextually appropriate points.]*

### "Don't Talk About Math"

I was interviewed recently for a *Prime Time Live* story about math achievement in the U.S. The producer was smart, but he didn't know very much about math, and he was trying to get me to talk about math instruction. Unfortunately, every time I would start talking about how teachers teach math he would say, "Wait, don't talk about math." I told him that it's hard to talk about math *teaching* without talking about math. His response was that people don't want to hear about math; they don't care about math. And I said, "Well, there's your story, isn't it? You're asking me why students aren't learning math at the same time that you're telling me no one cares about it."

### A New Perspective on Math Teaching: The TIMSS Video Study

The new study that I want to talk with you about today is the video component of the Third International Math and Science Study (TIMSS). This study was conducted in 41 different countries, examining student achievement in fourth, eighth and twelfth grades. As part of this study, the U.S. decided to do something that had never been done before: they took a national probability sample of teachers in three countries—the U.S., Germany and Japan—and videotaped them teaching in their classrooms.

This all started about five years ago when the government was beginning to design the TIMSS and decided it wanted to gather not just student achievement data, but data to help explain cross-cultural differences in achievement. Some of the key people involved in designing the study got the idea that teaching might be one of the key factors in differing student achievement outcomes, and decided they wanted to study this. Because I had done research on cross-cultural learning differences, I was asked to participate as a consultant.

Their initial approach was to develop a questionnaire teachers would fill out to describe their own teaching methods. I suggested it would be impossible to study teaching with a questionnaire. Teaching in the U.S. is largely a private enterprise; because teachers generally work in isolation, without a lot of consultation or teamwork, there is hardly even a common language of classroom practice. A teacher might check on a questionnaire that she uses "problem-solving" as a classroom teaching technique because of a group activity she uses, an activity that another teacher might not regard as "problem-solving" at all. Then when you add in the complication of studying across cultures, going to teachers in Germany and Japan, it just becomes inconceivable that you could ever know what a questionnaire's results meant.

Instead, I suggested a video study. These had been done before, but typically only on a small scale by researchers studying just a few classrooms. The project had three videographers; one Japanese, one German and one American. They traveled for seven months, all over their respective native countries, visiting a different school every day or two. At each school they would go to the teacher and the period we had randomly selected and videotape one lesson in the classroom. When we got the tapes back, we assembled a group of experienced math teachers from each nation, and reviewed and

analyzed and argued over what we found on the tapes. Gradually, we came to agreement on what certain elements meant and how we were going to define the various terms we were using in the study.

Today I want to talk about:

- why this is an important study;
- what we can learn from it; and
- what the implications of the study are for improving math instruction.

## Lessons From the Study

There are two very important things we can learn from this study:

- *we can learn what's actually happening in the classroom*

If the purpose for all the policies we're putting into place as a state is to improve classroom instruction, or more specifically, student achievement, the "final common pathway" (as a colleague of mine calls it) is the classroom. Everything we do at the policy level eventually has to go through the classroom, especially in mathematics. What's amazing is that we have virtually no information at all about what's actually going on in the classroom.

During their deliberations, the Math Task Force talked at length about the current math curriculum framework—is it good or bad, is it unbalanced, does it need more of a conceptual emphasis? I asked, what kind of data do we have that might tell us how well the framework is functioning in the classroom? And there is none. The result is that people are talking right now about revising the math framework as though it will affect student achievement, without any information at all on whether the framework has ever been implemented in our classrooms. One of the recommendations of the Task Force was that the state should collect data regarding the implementation and effectiveness of the framework; there is $250,000 in the state budget in support of this recommendation, but no study has been done yet.

## Taping Methodology

*Q: How many tapes did you make?*

In Germany we had 100 tapes; in Japan we had only 50. From the beginning, Japan only agreed to do 50, because they said "We're all alike, we don't vary, so you don't need as many tapes to represent Japan." We had 81 tapes from the U.S., covering 37 states. When we did the sample, we didn't do any substitutions, because we didn't want to take any chances of biasing the sample. We had a school, a teacher and a class period selected randomly; every math student in the U.S. had an equal probability of their teacher being selected for this study. Of course, a lot of people wanted us to do substitutions. Almost every principal we called would say, "Hey, the study sounds great, but you don't really want to tape Ms. Jones, you want to tape Ms. Smith, because it will be a lot better for you, believe me." And we would respond, "No, we have to have Ms. Jones or you can't be in the study." And we'd go to Ms. Jones and say we needed to have her third period class, and she'd say "That's not going to work out, actually, but fourth period would be fine." And we'd say no, we have to have third period or you can't be in study. So we got a true random sample.

*Q: What did you do about the language barrier?*

We translated every tape into English and used the English translation to come to agreement on terminology. But the actual coding of the tapes was always done by native speakers of the language being used in the classroom.

*Q: How many teachers refused to be videotaped?*

Nineteen, in the United States. None, in the other two countries. They have different systems of getting people to agree to things (laughter).

- *we can gain access to alternative models of teaching*

Let me illustrate why I think this is so important. I assumed going into the study that the results from Japan would show a fairly homogenous teaching style. It is a very homogenous country culturally and linguistically, and it has a national curriculum, so this result was to be expected. What was shocking was how homogenous the American lessons were, in terms of the basic approach to teaching math. This was especially surprising because American teachers value autonomy and the education system as a whole values local control. The general standard is that every school district needs to decide what's appropriate for its teachers, and every teacher needs to decide what the best way is to teach his or her students. But whether we were in Montana or Harlem or Mississippi or California, the approach to teaching math looked pretty much the same. We could have had a sample half the size that we did and gotten just as good an indication of what exactly was going on in eighth grade math classes nationwide.

## How Strong is the Cultural Influence on Teaching?

*Q: You've suggested that teaching has changed very little over the years. Is that how you really see it?*

I would love to have video samples of teaching from 1897 all the way through 1997. (By the way, they're actually considering putting a videotaping component into the next National Assessment of Educational Progress.) We don't know the answer for sure, although I do suspect it hasn't changed a lot. Incidentally, all the German teachers teach in pretty much the same way, and yet it's completely different from the way the U.S. teachers teach. I recently also got hold of a data set on Italian teachers, and they have a distinctly Italian style of teaching that is very different from the German and completely different from the Japanese. I believe teaching is highly culturally determined.

I think that's a very significant outcome, because it means that the old saying that "we teach the way we were taught" is probably true. Teaching is a cultural activity. Each of us grew up being exposed to certain kinds of instruction. If I said "Come up here and teach a math lesson," your intuition of what to do would probably be just what we saw out there in classrooms around the country. When I show American

## A Cross-Cultural Look at Teacher Training

*Q: What you're saying about teachers all teaching the same way suggests either that teacher training makes no difference, or that teacher training is teaching everyone the same way.*

My personal opinion is that teacher training doesn't have a lot of influence on teaching. Teaching is a complex cultural activity, and changing things of that nature takes a lot of time and has to be done gradually, in small steps. Yet our whole approach to teacher training is that students are supposed to know how to teach when they get out of teaching college. We put new teachers in a classroom by themselves and in two years, they're up for tenure. New teachers often know very little about what they're supposed to be doing, but feel like they have to behave as though they know everything, since they'll be up for tenure so soon.

In Japan, there's no such expectation; in Japan, they say it takes about ten years to really learn to be a teacher. They have what amounts to a lifelong process of gradually socializing new members of the teaching profession. They believe it takes a long time and tremendous resources to train teachers properly and they have no expectation that new teachers will know anything about teaching when they get out of college.

**Continued on next page**

## The Money Question: Teacher Induction vs. Class Size Reduction

*Q: Who decides how education funding is spent in Japan? It seems like they must spend a lot on induction (professional assistance to new teachers).*

The federal government has a huge influence on how money is spent in Japan. The main way they're able to invest this much in in-service teacher training is by having large classes. The typical class size in Japan is around 40. They believe there is a real trade-off between class size and how much free time teachers have to devote to their own professional development, and they have taken a very definite stance on that trade-off, just as we have on the other side of the same trade-off. Here in California, the Governor chose to spend extra education dollars that came along to reduce class size, rather than to build the best professional development programs in the country. That would have been an alternative, but I don't think it ever crossed his mind. In Japan, they also have a much higher percentage of school personnel with direct classroom teaching responsibilities than in the U.S.

teachers these tapes, the most common response I get—from anybody, no matter how old they are—is "That's my math teacher." It's very, very familiar.

To me, this just underlines how important it is to get this information from other countries. One of the themes of my research has been how looking at other cultures can really clarify what you see in your own. We don't see the commonality of American approaches to teaching because it's so pervasive that we don't even notice it. We assume it; we look in a classroom and it just looks normal to us. What we notice are the things that look different, even though those things may not be the most fundamental, important characteristics of the way we teach mathematics.

## Study Methods

It's important in talking about what we learned in the study to look also at the methods we used.

I mentioned before that we took all the lessons we transcribed and everything that was said and translated it all into English. We had to do that in order to analyze what was happening in the lesson, because it all goes by so fast. The other thing we did was to make a table summarizing the mathematical content and flow of every lesson. This was another tool that we used to help the coders keep track of what was going on in the lesson.

**Teacher Training/continued from last page**

By law in Japan, your first year of teaching you have 60 full days of in-service training. You spend most of your first year in your classroom with a master teacher as your mentor. You also have a number of required off-site workshops. One veteran teacher told me about his first-year routine. Eight times during the first year, he would be observed by his colleagues—all 70 of them. They would crowd into his classroom on a short day (generally getting out at 1:00) and observe closely as he taught the lesson. The rest of the day would then be spent in a group session where they would critique his lesson. Rather than talking about his strengths and weaknesses, though, they would hit him with every negative piece of criticism they could come up with. And then at the end, after three hours, they would tell him how glad they were to have him be a new teacher at their school, and they would all go out together and drink whiskey and celebrate.

The way this teacher explained it, the whole reason for this is that when you get out of college and think you know it all already, the first thing you have to learn is that you know nothing about how to teach. The whole idea is to make you feel unprepared to teach, so that you will be more open to learning from all your colleagues in the profession who have years of experience behind them.

Four math professors from the UC system helped us analyze the mathematical content of the lessons. They did it blind; we disguised the nationality of the teacher and students before we turned over the transcripts for them to analyze, making this probably the most objective part of the entire study. They spent ten months analyzing the data, looking at what kind of learning opportunities and opportunities for mathematical thinking were present in each lesson.

One of the exciting things about video data is that it really facilitates interdisciplinary analysis of educational problems. It also clarifies so many issues by giving them a real-world point of reference that's too often missing from policy debates. I think far too much of the debate over education policies today goes on divorced from actual examples of teaching in the classroom. One of the great things about video is that you can see right away what you're talking about in one of these policy discussions.

## Study Findings

Two kinds of findings come out of study like this. First, there are the quantitative indicators, where you count up elements you see on the tapes such as subject matter and use of specific teaching strategies and quantify them. Second is qualitative data, the things you learn by watching the tapes. Both are very important.

The qualitative video images are very important, because they provide the real-world grounding for the entire discussion of the quantitative indicators. It gives meat to the discussion if we can point to an image that illustrates exactly what we're talking about. On the other hand, video images can be extremely misleading if you're not careful of how you use them, because they're very powerful. You can select a video image as an example of German teaching style that's very accurate, or one that's very inaccurate, and that's why the quantitative data is so important.

### The Socialization of New Teachers: Very Important and Very Hard to Change

*Q: You said teachers teach what they're taught; you could also argue teachers teach what they know. Most American teachers' understanding of math fits the way that they're teaching.*

Yes, that's true. That's a huge problem. If it's true as I've said that most American teachers teach using the same approach their teachers used, then you can't generate change using the normal ways of socializing people into the profession. In Japan you have a whole range from senior teachers down through novices and the whole system is designed around getting the novice teachers to be socialized by experienced teachers into their system of teaching. But what if you wanted to change the whole system of teaching? How would you do that? It's a very interesting problem.

### Different Cultural Valuations of Teaching

*Q: How much training do Germany and Japan give their math teachers?*

They don't necessarily have more courses than American teachers (pre-service training in the U.S. is actually longer), but they definitely know more mathematics because by the time they graduate from high school, they're about four years ahead of American math students on average. Then, to top it off, Japanese teachers typically come from the top half of their academic class. Teaching is a highly desirable career in Japan—you have to compete to become a teacher there. In the United States, if you're strong academically, chances are people will tell you "Don't be a teacher, be an engineer or a lawyer or a doctor."

Another reason quantitative data is important is that it gives the researcher the opportunity to make a hypothesis based on viewing one or a few of the tapes, and then go into the database and test that hypothesis against the overall findings of the study. Sometimes the statistics will bear out an idea you get about German teachers while watching the tapes, and sometimes it will turn out to have just been something your attention was drawn to that day.

## A Look at the Quantitative Indicators

♦ *incidence of outside interruptions during a lesson*

We measured how many times the lesson was interrupted by someone coming into the classroom or an announcement coming over the public address system. This happened during 31% of the American lessons, 13% of the German lessons and *none* of the Japanese lessons. You might expect there would be some element of bias here, with people trying to avoid disturbing the class being videotaped, but interruptions still occurred in almost a third of the U.S. classrooms.

One of the interesting insights we gained in the study was that this finding came as a total surprise to the Japanese professors analyzing the tapes. They had no idea what the public address system was the first time an announcement came over it on one of the American tapes. They couldn't believe that someone would interrupt a math lesson and distract the students like this. This underlined the differing cultural expectations American and Japanese teachers have of what is supposed to happen during a math lesson. A Japanese lesson starts and ends with a bow and is a coherent, highly valued

### "Juku" and Japan's Culture of Learning

*Q: Your comments about the amount of attention paid to tests were interesting. There are obviously some real differences between teaching in Japan and in the U.S. But isn't there a great deal of awareness in Japan of the big exam they all have to take in ninth grade? Don't a lot of them go to special afterschool programs to prepare for the test? And have you gotten Japanese teachers' interpretations of these issues?*

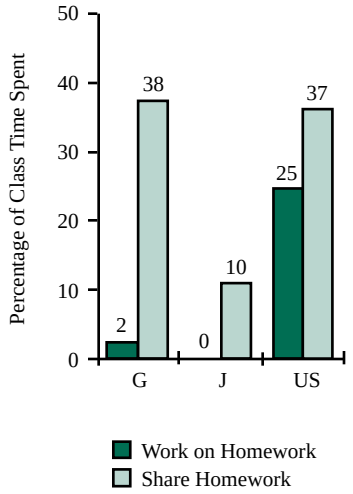
We've had a lot of opportunities to have Japanese and German colleagues' interpretations of these tapes. And yes, many Japanese students do go to "juku," the so-called cram schools, after the regular school day is over. But the real point is that teaching is part of a cultural system, and that makes it tremendously difficult to tie differences in student achievement to any single difference in the way the material is taught. Some Americans might think that since Japanese teachers don't do the "drill-and-kill" routine in the eighth grade math class, they must do it in juku. We're finding that they don't. We like to feel that somewhere, they must be doing this. People used to think Japanese teachers must drill-drill-drill all the time in the classroom. But they don't—*we* do. So then people started thinking it must be the parents who do the drilling at home. But then we found out that Japanese parents play a very different role from American parents; they commiserate, they say "Oh you poor thing, please take a break and just watch some TV," and it's the kids who say "No, Mom, I have to study." When you actually look at the dynamics of the Japanese family, it's very different from what we're accustomed to in the U.S. We're learning right now that the same is true of juku. Juku is a big business in Japan, and they are all privately run, so they won't let you come in and do a study, but we are learning that kids do a lot of different things in juku, including sports and music and art classes. Many juku are now focused on fostering creativity, which many Japanese believe their culture has not historically nurtured enough.

event that you would never just walk in and interrupt. The Japanese lesson is like a church service; the U.S. lesson is more like a trip to the supermarket.

- *the role of homework in a lesson*

We've all been conditioned to believe that the Japanese work their students relentlessly with homework assignments. Yet we—and the TIMSS study as a whole—found very little emphasis in Japan on homework, especially by the time you get to eighth grade. In our sample, only 24% of the Japanese teachers had assigned homework for the lesson we videotaped, whereas over 90% of the American teachers had.

**Table I**
**Role of Homework in the Lesson**




We looked at lessons that included working on homework, and ones that included sharing homework (see Table I). Many American and German lessons started out by going over homework. After that they would do a little development or teaching, and then if there was time left, American teachers would get their students started on the next day's homework.

This gave a very distinct impression of the differences in how the teacher's role is perceived across these cultures. A great deal of the American math teacher's role seems to be simply managing homework; checking that it has been done, going over it, assigning the next day's homework, getting started on it and helping individuals with it as the class works on it. Japan, on the other hand, had the least emphasis on homework.

We developed the idea from the homework data that the American teacher's role is essentially managing practice—you hand out homework, check that they did it, hand out more and test on it. Japanese teachers look at what they're supposed to be doing in the classroom in a very different way.

This brings up a related element: the relative emphasis on testing. The common belief is that there is a huge focus on testing in Japan. It is true that in ninth grade, Japanese students take a very high stakes exam that will determine their chances of getting into the high school—and ultimately, the college—that they want to go to. But the Japanese teachers

## Japan: Focus on Problem-Solving

*Q: Do you think it's fair to say that Japan has adopted the National Council of Teachers of Mathematics (NCTM) standards?*

Not really. In some ways they have; there's definitely more genuine problem-solving going on. There are more students having to explain their thinking. There are very rich mathematics going on during the lesson. On the other hand, in other ways they don't look like the NCTM at all. They're highly teacher-directed. They lecture more than teachers in any other culture I've studied—although they prime their classes well by challenging students to try to solve the problem first, so that they become very interested in learning the solution in the lecture that follows.

never mention tests in the classroom during a lesson. And the students never say "Will this be on the test?" There was no discussion of tests whatsoever, whereas in the American classrooms, almost every lesson included some discussion of or questions about the test and what might be on it.

♦ *level of math being taught*

The level of math being taught was completely different in America and the two other countries. Eighth grade math in Germany and Japan was algebra and geometry, whereas in the U.S., 40% of the lessons in our samples were pre-algebra arithmetic.

♦ *use of concepts and methods in lessons vs. use of applications*

We found that 47% of the American lessons only included applications, without any reference to any kind of a math concept in the lesson; that is, teachers taught students that *A* to the *M* power divided by *A* to the *N* power equals *A* to the *M minus N* purely by repeating examples, rather than stating the underlying math concept. This was very rare in Japan and Germany.

Perhaps even more interesting were the results when we looked at "developing" the concept versus simply stating it (see Table II). We counted as "developing" the concept even the simplest expansion beyond merely stating it, i.e. writing out the five *A*s over the 3 *A*s on the chalkboard and reminding the class how the numerator and denominator cancel out to *A times A.* Approximately 80% of the concepts in the U.S. were only stated and never developed, whereas in Germany and Japan the exact opposite pattern occurred.

**Table II**
**Math Concepts:**
**Stated vs. Developed**

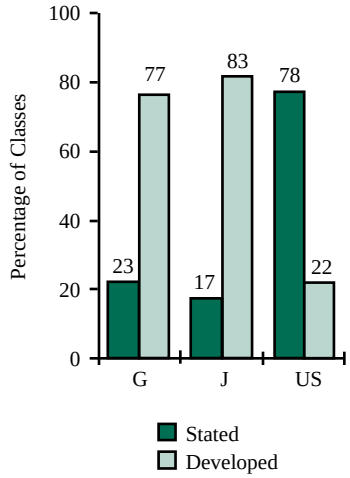
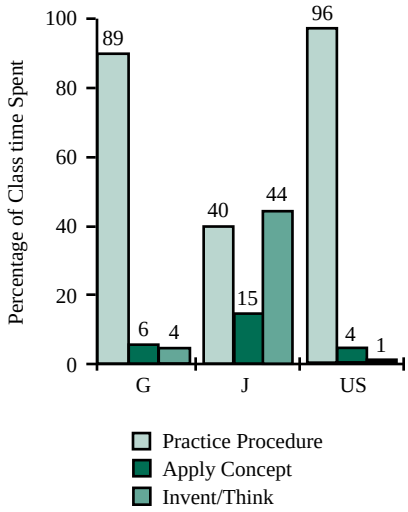



**Table III**
**The Purpose of Seatwork**



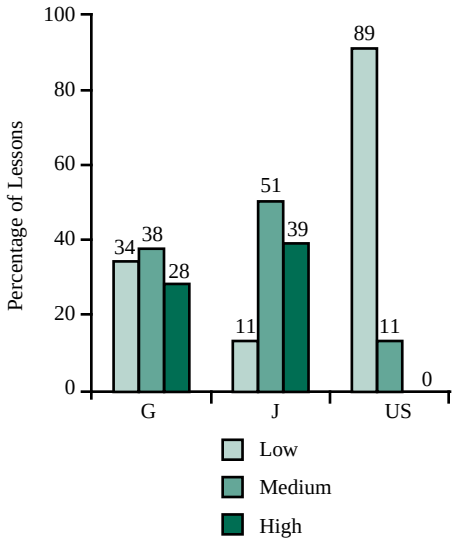

♦ *performance expectations in seatwork*

We distinguished between three levels of tasks we saw assigned in seatwork: the simplest, practicing a routine procedure; the middle level, applying the concept behind the procedure to a new problem; and the most complex, either trying to come up with your own method for solving the problem, or trying to prove that the method being used would always work (see Table III).

Here, Germany and the U.S. are virtually identical—the purpose of seatwork is to practice the procedure being taught. In Japan, by contrast, teachers placed much more emphasis on getting students to come up with new ways to solve a problem that they've never seen before or to use mathematical reasoning to prove something. Fifty-four percent of the Japanese lessons included proofs. *None* of the American lessons included proofs.

Notice that in German classrooms, unlike in American ones, math concepts are developed; it's just that in Germany it's the *teachers* who do the developing, whereas in Japan it's the *students* who develop the concepts. The German teachers give lectures and work through theorems on the board and then ask the students to practice doing the same problem. The Japanese teachers put a problem on the board that forces the students to try to figure out how to do it themselves.

**Table IV**
**Math Content Ratings**




♦ *quality of mathematical content*

We also asked our mathematician analysts to do a global content rating on each math lesson (see Table IV). They made these judgments blind, without knowing which country the coded results they were looking at came from. None of the American lessons got the high rating and 89% were rated low in the quality of math content; the German lessons were fairly evenly distributed; and 90% of the Japanese lessons were of medium or high quality in their math content.

♦ *percentage of teachers who use the chalkboard or overhead projector in math lessons*

Among the German teachers, 92% used the chalkboard and 25% used the overhead projector; in the U.S., 67% used the chalkboard and 57% used the overhead projector; and in Japan, 100% used the chalkboard and only 6% used the overhead projector. It's interesting that U.S. teachers use the overhead projector more than anyone else, and that use of an overhead projector is in fact a real rarity in Japan. That's not because Japanese teachers don't have access to them; it's because they have decided overhead projectors don't help them teach. It's also interesting how things like this sometimes are latched onto by U.S. policy-makers as panaceas for making U.S. schools work as well as Japan's. "If we just lengthen the school day," they think, "we'll be more like Japan and our students will learn more." It's not much of a stretch to imagine someone introducing a bill to confiscate all the overhead projectors in the state based on this finding.

The real question we should be paying attention to, though, is this: how are Japanese and American teachers using tools like the chalkboard and the overhead projector? American teachers typically behave as though the role of the chalkboard—and the overhead—is to help them focus students' attention. They flash an image or a concept and then move on to the next piece of the lesson, erasing or removing the previous element. Teachers in the U.S. typically use visual materials and active body language in a constant battle to draw every student's attention to their words.

In Japan, they have a very different philosophy of how visual materials should be used. Their philosophy is to treat the chalkboard as their (and their students') record of the entire lesson being taught. They start writing on the left side of the board, introduce a problem, examine various solutions and concepts for solving the problem, and end on the far right of the board, rarely erasing previous steps. Teachers in Japan believe students aren't *supposed* to follow everything all the time; they *expect* students to daydream some of the time. So they design a lesson structure that allows students to daydream and then come back into focus a few minutes later with an entire visual record of the lesson in front of them that will allow them to get back into the flow. Japanese teachers actually plan a lesson by deciding what the blackboard is going to look like at each stage of the lesson.

We have very different cultural models about what students are supposed to be doing during instruction. American teachers think the teacher's job is to keep the student focused. So American teachers are very active most of the time, they talk about tests frequently, they tell jokes and they often go through rapid-fire series of visuals. Maybe even more so than the Japanese, the Italian classroom is the complete opposite; the teacher sits passively as the students do everything—and the students are all engaged in the lesson.

Ultimately, what is most important to examine here is not the indicators, but the underlying systems of teaching and the beliefs and assumptions that drive them. We have to be very careful about assuming we can manipulate the indicators and change what's happening in the classroom; there is no reason to believe that would happen. Taking away the overhead projectors won't make American math students achieve like Japanese math students. You have to look at *why* the Japanese teachers don't use the overhead—because their approach is to create a lasting visual record for the student to follow throughout the lesson.

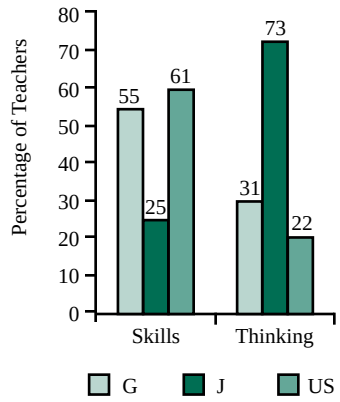
### Student Note-Taking

*Q: Did the students in the study copy down everything on the board? What kind of notes did they take?*

In Germany and Japan they took very detailed notes; in the U.S., it was very haphazard as far as what would end up being written down. I believe a lot of the difference stems from the fact that German and Japanese teachers begin teaching kids early in elementary school how to take notes and what kinds of things they should be writing down, so that by eighth grade, they know exactly what to do. Plus the teachers use different colored chalk and the students have different colored pencils, so the students are able to color-code their notes to match the chalkboards, and they are able to go back and study their notebooks and have a very good record of what happened in class.

If you took the overhead projectors away from the American teachers, you'd find they would use the chalkboard the same way; present one piece of the lesson, erase it and move to the next. In fact, we coded the tapes according to how quickly information written on the chalkboards was erased. The "half-life" of an object on the chalkboard in the U.S. was very brief; in Japan, objects tended to stay on the board a very long time. The Japanese also often used posters that had been prepared in advance. It's like the overheads in that you can prepare it in advance, but the Japanese want to be able to leave it up for the entire lesson, so they use posters.

**Table V**
**Goal of the Lesson**




It's very important to see how these teaching tools get filtered through the beliefs and the cultural systems that define what teaching is in each country. It explains a lot about how and why education reform does and doesn't work in the United States, because no matter what you direct teachers to do, they filter it through their own system. If you told American teachers not to use the overhead, they would say "Okay," and then they would use the chalkboard the same way they had been using the overhead. It doesn't really change the fundamentals of the teacher's style.

- *what math teachers are trying to accomplish in their lessons*

Here we did use a questionnaire that teachers filled out after being taped, and we found a very big difference between Germany and the United States on the one hand, and Japan on the other, in terms of the goal of the lesson (see Table V). German and American teachers saw the primary goal of the lesson

as teaching their students how to solve problems. The Japanese teachers saw the primary goal as teaching their students math concepts, what they mean and how to think about math in general.

- *diversity in the classroom*

What's extremely interesting about all this is that, paradoxically, a lot of the teaching techniques that the Japanese have developed work especially well in highly diverse classrooms (i.e., ones where students have a broad range of academic skill), and the techniques that American teachers have developed work especially well in homogenous classrooms. You might expect it to be the opposite; we're a very diverse society, so we ought to be the specialists in how to teach in diverse classrooms.

But we take a completely different approach to managing individual differences. Our approach is to track students and divide them into groups by ability, so that teachers end up with academically homogenous classrooms. In Japan, they do no tracking at all before the tenth grade, assignment to classrooms is completely random and classes and schools are very big, drawing together a relatively diverse student body. By the time all these factors on both sides come into play, Japanese classrooms end up with greater variability in student achievement than American classrooms.

## The U.S., Germany and Japan: Teaching From Different Scripts

Based on the respective teaching goals identified in the study, we can define two simplified "scripts" for math lessons:

### I: U.S. and Germany

- teacher instructs class in skill or concepts
- teacher solves example problems with class
- students practice while teacher helps individual students

### II: Japan

- teacher poses rich problem
- students struggle with problem
- students present ideas / solutions
- class discusses methods used
- teacher concludes (or, a second problem)

We did some additional research using the TIMSS tapes in which we asked Japanese and American teachers to evaluate what they saw on the Japanese and American videos in terms of strengths and weaknesses observed in the teaching approaches used. The Americans' most frequent comment was that the Japanese students seemed confused, and that the teacher wasn't being very clear about telling them what they were supposed to do. Of course, from the Japanese perspective, that's the whole idea—the teacher *doesn't* tell them what to do; they have to figure it out themselves. American teachers don't like students to be confused—they think that's a sign the teacher is doing a bad job.

In contrast, the Japanese teachers believe that confusion is an extremely important part of the learning process. They actually place explicit warnings in some lesson plans *not* to correct common errors made by students attempting new math concepts (for example, trying to add fractions by adding the denominators), because if you correct them prematurely the students will never understand the logical ramifications of attempting to solve the problem using the wrong method. American students are taught "Don't add the denominators," and they don't—but not because they understand why adding them doesn't solve the problem. They don't add them because the teacher told them not to.

American students are given a rule and told to follow it; Japanese students grapple with the logic behind a rule and then apply it. We look at math as skills; the Japanese look at it as concepts, and the interrelationships among those concepts.

## Videos and Reaction

*(At this point Dr. Stigler presented, first, a video of an American math lesson featuring a teacher who typified the style and approach seen among the American teachers in the study, and then the same for a Japanese math lesson. In each case, after the video was shown, several threads of reaction emerged from the group.)*

### Reactions to an American Math Lesson

The group noted that:

- the teacher used what was essentially a drill approach; there was no active learning going on;
- he used the "known-answer" question technique a lot ("A triangle has how many sides?");
- the teacher was very careful to control exactly where his students' thinking went; he led them along through each step, keeping them focused very tightly on what to do next;
- he basically broke a geometry problem down into a series of addition and subtraction problems without exploring the underlying concepts;
- the emphasis was on computation and terminology—it was more a language lesson than a math lesson;
- every mistake he highlighted in students' responses was identified as a computational error rather than a conceptual error;
- there was no effort to assess why the concept being taught is true, no logic was offered in support of the formula being taught, and the students seemed to accept this as normal;
- questions from students were rare (this is true of 8th graders in both the U.S. and Japan); and
- the deep message appeared to be that the teacher didn't believe the students could handle the material and needed to be led through step by step.

### Reactions to a Japanese Math Lesson

The group noted that:

- the class was large;
- the class spent the entire period addressing one problem;
- the "wait time" between each statement made by the teacher was much longer in Japan than in the U.S.; the American pace did not allow students to really think about the problem, where the Japanese pace did;

- unlike his American counterpart, the Japanese teacher asked a lot of questions he could not have been certain of the students' answer to, for example "How would you do it?" "How do you know?"
- it was harder to determine what the objective of the lesson was;
- the Japanese lesson focused on intuition and creative problem solving, where the American lesson focused on terminology and computation;
- the Japanese approach underscored why proofs are important teaching tools, by emphasizing the logic behind concepts;
- there were no significant differences in the availability of technology—both classrooms had computers available, though only the American students used calculators;
- like the American lesson, the style of the Japanese lesson seemed to suit and meet the expectations of the students; and
- Japanese students appeared to take math more seriously than American students.

## Can We Change the Way Americans Teach Math?

*Q: The message I hear from this study is that we should not underestimate the cultural differences underlying the teaching approaches in the U.S. and Japan. If the U.S. wanted to move toward a more conceptual approach like that used by the Japanese, what should we do?*

The real question, I think, is whether we really want to try to teach like the Japanese. My answer is that we shouldn't, not because there aren't certain aspects of Japanese style that could be useful, but because it is so difficult to change teaching in the U.S. Every time we've tried to change by adopting some sort of new model or tactic, we've simply adapted that new idea to our culturally-programmed mode of thinking about teaching and how to do it.

We asked teachers in this study about their awareness of current ideas about the best ways to teach math. The overwhelming majority said they were very aware of these ideas, that they've read the National Council of Teachers of Mathematics (NCTM) findings and other state reports on math instruction. Then we asked if they had implemented these ideas in their classrooms and again, an overwhelming majority said yes. Then we asked them if we would see evidence of them having implemented these ideas in our videotapes of their teaching and once again an overwhelming majority said yes. And we asked them to cite examples.

What we found was that they have adopted surface features, such as using real-world problems, using calculators and using cooperative learning, without changing their basic teaching philosophies at all. One of the main things I learned from this study is that many of the "standards" documents have caused us to focus on surface features rather than what the students are learning, and they may have diverted our attention in a very unfortunate way. We saw so many examples in our U.S. data set of teachers who have taken a new idea and, in implementing it, have unconsciously transformed it into an extension of the same basic approach to teaching they have always used.

Our whole approach to changing teaching has always been to have experts meet and do research, write up documents that explain what good teaching is and then widely disseminate the best results. This study showed that we have been very successful at getting teachers to read these materials and take them seriously, but it hasn't had the effect that we intended.

It's very interesting to look at how they try to improve teaching in Japan. The Japanese have an entire research and development system for the gradual, constant improvement of teaching. Their teaching style has gradually evolved over the past fifty years. Their approach to improving teaching isn't indirect; they don't believe that publishing a book that says "teach this way" or reducing class size, or bringing computers into every classroom is going to materially improve the quality of teaching in the classroom. They look at teaching itself, examine it and constantly try to improve it.

The essence of the Japanese approach to improving teaching is "lesson study." Lesson study is school- and subject matter-based. Teachers at a school will choose a specific topic (for example, adding fractions with unequal denominators) and may work on that theme for three years, meeting every week in their lesson study group. They plan a lesson together, assemble the materials and review every detail from start to finish. They might work on planning the lesson for six weeks, meeting for two or three hours every week. Then they present their plan to the faculty of the school, receive criticism and revise the lesson. Then one of the teachers teaches it to a real class while the others in the group watch and study what the students are doing during the lesson. Then they meet, review the results, revise the lesson again, another of the teachers in the group teaches the revised lesson in front of the entire faculty, and then they have a three-hour meeting

to receive more criticism. And then they go back and revise the lesson again. At the end of the year, a "lesson fair" is held where all the teachers in the region get together and look over each other's work on lesson planning.

So they will spend an entire year working on one lesson. The transcripts of these lesson study meetings show an attention to detail that is truly astonishing to most Americans. American teachers would say "Let's give them a single-digit subtraction problem," and then move on to the next element of the lesson. The Japanese teachers would ask each other "Should we give them 12 minus seven or 13 minus seven," and then have a one-hour discussion about the different things that might happen depending on which example was used. They would consider every conceivable type of error the students might make and whether they wanted to address those errors in that lesson.

There are a number of interesting characteristics of the Japanese approach:

- there is no concept of "reform" in Japan in relation to teaching—their concept for teaching is of continuous improvement, step by step;

- ideas about improvement are deeply grounded in the classroom context—when they create a lesson that works, they do it with complete confidence because they have watched it work in a real classroom; and

- the process involves strong, continuous collaboration among teachers.

At the end of the year teachers engaged in lesson study write up a research report that documents all the steps they went through in constructing the lesson and what they discovered, and they publish it. Because Japan has a national curriculum, what these study groups discover is highly shareable, widely useful information. This results in a system where, instead of teacher training being a mechanism used to help teachers teach better, it becomes a process which allows teachers to feel that their development contributes to the profession as a whole by improving collective knowledge about teaching.

I don't think there's a single American teacher who believes that by participating in training they're going to improve the profession's *collective knowledge* about teaching. In Japan, virtually every young teacher involved in the process of lesson study believes that they're contributing to the step-by-step, gradual improvement of teaching. The American approach, in which we identify how we think teachers should be teaching and then push them to teach that way, causes a pendulum-swing effect as we push everyone one way, and then student achievement doesn't go up, and we "reform" off in the other direction again. Japan has a sense that gradually over the last fifty years, their quality of teaching has gotten higher and higher, and I don't think we can say that about teaching in the United States. In the U.S. we can look back and see various swings in policy, but I don't think we can see gradual improvement.

What the United States lacks is a mechanism for learning from our experiences in the classroom. There are perhaps a few thousand researchers in the country studying teaching strategies, but there are two and a half million teachers out there trying out new ideas and discovering what works and doesn't work in their classrooms every single day. What we need is a mechanism to collect that experience together and capitalize on it, using it to benefit the profession as a whole. To me, the most interesting thing about Japan to come out of this study isn't the way they teach mathematics; it's the way they learn to teach mathematics.

## Current U.S. Efforts to Bring Teachers Together

*Q: We have efforts here in the state like the Subject Matter Projects that are meant to be collaborative and involve teachers in summer workshops. Ted Sizer has the Coalition for Essential Schools, which has the "critical friends" groups where teachers get together and talk about teaching. What do you think of these efforts? Could they help, or do they miss the mark somehow?*

Anytime teachers get together as a group, they love it, because they tend to be so isolated in their daily work. Bringing teachers together is inevitably positive. The problem is that the one thing teachers never do in these groups is work on designing, teaching and jointly critiquing a lesson. That is the most fundamental difference from the Japanese experience. Groups of teachers tend to get together in the U.S. for support and sharing ideas, but not to go examine classrooms together and design a lesson that works better than what they do now. I don't think those groups ever imagine themselves as researchers working to improve the teaching profession.

*Q: How about the case study groups? Are they closer to the Japanese approach?*

The case study groups actually come closer. There are groups where people study cases in somewhat the same way students do in business schools. But those cases are designed with a certain idea of how you're supposed to teach in mind, and the cases are selected to illustrate a certain kind of instruction. The Japanese assumptions about teaching are fundamentally different. They don't believe there's a good way to teach or a bad way to teach; they believe you can always improve. Their goal is not to figure out how to get the teachers to teach the way everyone thinks they are supposed to teach; their goal is to look at the way they teach now, figure out a way to improve it and share that improvement with other teachers so they can use it too.

## The American Approach to Lesson Planning: A Lesson in Itself

*Q: Could you expand on how the American approach to lesson planning is different from the Japanese?*

I once asked a group of American teachers to create a lesson plan. They took fifteen minutes to do it. I asked them "Is that all the time you need?" and they said yes, we've planned it all out; first we're going to do this, and then we're going to do this and then this. The American plans always say what the teacher is going to do. The Japanese plans ask what the students are going to think if the teacher does this. If they think "A," then the teacher's next step should be "X." If they think "B," then the next step should be "Y" and so on.

Then I asked one of the American teachers to teach the lesson, and we all went to watch. It was a complete disaster; everything went wrong. Then I asked them to revise the lesson, and this time it took them two months. Suddenly, after having had the opportunity to watch the lesson unfold in the classroom—and later, to review a tape of it—they found it wasn't a stretch at all to spend eight weeks, two hours a week, figuring out what the lesson's flaws were and determining the best ways to fix them. We ended up going through the test-teaching-and-revision process twice more.

The cultural issue here is that American teachers don't have any experience jointly talking about instruction. When they get together, they don't talk about lessons. They talk about all manner of other professional and personal issues, but almost never discuss how they actually teach their students. Japanese teachers, on the other hand, have a very theoretical approach to teaching; they are very practiced at going through and analyzing lessons. Furthermore, they have a common research literature, so that when a teacher goes to plan a lesson, he or she has a very good idea what the probable outcomes of posing a particular problem are. The emphasis on invention and forcing students to think problems through in

Japanese classrooms really isn't a matter of the teacher not knowing what the student's response may be; he or she has almost always already studied the potential answers and inventions and anticipated them.

## Why are We So Different?

*Q: You've identified a lot of differences between approaches to teaching math in Japan and in the U.S., but do you have a hypothesis that accounts for these differences? Why do the Japanese do things the way they do?*

I believe it's very complex. Part of it is our very different philosophies of what it means to learn something and what it means to understand something. I think that Americans are very behavioristic in our outlook towards learning, even down to things like classroom participation. Teachers here want smaller class sizes in part because we want every child to have a chance to participate in class. Japanese teachers don't understand this point of view at all; they believe participation isn't saying something in class, it's having your brain engaged in the problem at hand. Participation, to the Japanese, is a mental thing. They believe you can have just as much "participation" with a hundred students as with twenty.

Americans have a whole set of beliefs about how students need to learn. We believe you need to talk to learn; the Japanese think you only talk when you're really seriously lost and have to ask a question. If you're thinking, they believe, then you're not going to be talking. These beliefs are very deep, and it's a difficult process to question them.

The idea that students construct knowledge rather than simply taking it in has taken hold both in America and in Japan. But the lesson Americans take from this is that you need to do a lot of one on one teaching. The Japanese believe that because all students construct knowledge, a good lecture will draw any number of them into the subject.

The other side of this is that within these basic beliefs about how students learn and teachers teach, the lesson study groups provide a way of introducing variation into the system in the right size steps so that they can actually be incorporated. The key to improving teaching is to ask the question over and over: "Can you think of a way to make students learn more?" If we had two and a half million teachers making tiny little discoveries that improve their own teaching—and then had a system for sharing them with other teachers, gradually, you would see change. You don't get to be a concert pianist by saying "I'm going to be a concert pianist." You get to be a concert pianist by practicing for years and years and gradually, over a long period of time, improving your skills. The Japanese look at teaching like that; gradually, innovations are introduced and over time, teaching improves. It's a very different way of looking at teaching.

*For a free VHS video (72 minutes) which lets viewers see first hand an abbreviated geometry and algebra lesson in each of the three countries (Germany, Japan, and the U.S.), contact: National Center for Education Statistics, 555 New Jersey Avenue, Suite #402A, NW, Washington, DC 20208; Telephone: (202) 219-1333; Fax: (202) 219-1736; Email:* TIMSS@ed.gov.

*To learn more about the TIMSS video study, visit the study's site on the World Wide Web at* http://www.ed.gov/NCES/timss/video/index.html. *The site includes links to the TIMSS and other websites relating to math instruction.*

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