THE FREE PRESS
A Division of Simon & Schuster Inc.
1230 Avenue of the Americas
New York, NY 10020

Designed by MM Design 2000 Inc.

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Stigler, James W.
The teaching gap : best ideas from the world's teachers for improving education in the classroom / James W. Stigler and James Hiebert
p. cm.
Includes bibliographical references and index.
1. Mathematics—Study and teaching—United States.
2. Mathematics—Study and teaching—Germany. 3. Mathematics—Study and teaching—Japan. 4. Comparative education. I. Hiebert, James.
II. Title.
QA13.S77 1999
510'.71—dc21 99-27270
CIP

ISBN 0-684-85274-8

Teaching Is a System

ALTHOUGH VIDEOTAPES are a rich source of information, they provide only glimpses of the full activity of teaching. We have found images of teaching in each country, and we have constructed indicators that measure the features of classroom lessons in each country. These images and indicators provide only partial views of teaching, however. It is as if we are seeing the peaks of mountain ranges poking above the surface of the water. The videotapes provide views of these mountaintop islands, but still hidden, underneath the surface, are the mountain ranges.

We discovered that mountain ranges lay beneath the surface as we asked ourselves why the indicators revealed certain differences among the countries. Consider the following simple indicator. Many mathematics teachers in the United States use an overhead projector, whereas almost all teachers in Japan prefer the chalkboard.' Some would say this is a trivial difference and not worth worrying about. But when we look more closely at this superficial difference we see that it points to a deeper, more significant difference in the way teaching is conducted.

When we look again at teachers using overhead projectors

and chalkboards, we begin to see that teachers in the two countries do not just use different visual devices, they use them in different ways. Most teachers in the United States use visual devices to focus students' attention. They use both overhead projectors and chalkboards to display information in written or graphic form while they are describing it orally. **As** they finish each part of their oral presentation, they often erase that part of the written material and move to the next item. Whether they use overhead projectors or chalkboards, they use these visual aids to keep students' attention directed toward the information of the moment. This observation is not a new revelation. Many preservice teacher-training programs offer advice on using overhead projectors in just this way. Readers who have participated in such teacher training might remember being told to cover up all the items on the transparency except the one being presented, then to move the cover down to the next item, and so on. When finished presenting the last item, the teacher is told to turn off the projector so as to reclaim students' attention.

Japanese teachers use visual aids for a very different purpose: to provide a record of the problems and solution methods and principles that are discussed during the lesson. The first item of information in the lesson is placed at the far left of the chalkboard; the next item, whether presented by a student or the teacher, is written next to it; and so on. The record builds, left to right, as the lesson proceeds. Many Japanese teachers finish the lesson with a full chalkboard, showing a complete record of the lesson.

The fact that **U.S.** teachers frequently use overhead projectors and Japanese teachers use only chalkboards indicates much more than a whimsical preference in visual aids. Given how these aids are employed in each culture, we can now see

that Japanese teachers would *not* use overhead projectors, whereas **U.S.** teachers would use either one but probably would find overhead projectors more effective. Visual aids function very differently in these two different systems of teaching.

And here is the significant truth about teaching that this simple-seeming indicator reveals: teaching is a *system.* It is not a loose mixture of individual features thrown together by the teacher. It works more like a machine, with the parts operating together and reinforcing one another, driving the vehicle forward. In the U.S. machine, or system, there is a slot for a visual aid that helps focus students' attention. The overhead projector serves this purpose as well as, or better than, the chalkboard, so it is easy to see why many teachers have shifted to the overhead. In the Japanese system, there is no such slot. Instead, there is a slot for presenting a cumulative record of the day's lesson. The overhead projector does not function in this way, so Japanese teachers do not use it; they continue to use the chalkboard.'

If teaching is a system, then each feature, by itself, doesn't say much about the kind of teaching that is going on. What is important is how the features fit together to form a whole. How does one feature connect with the next one? How does an activity near the end of the lesson link back with one at the beginning? This is a very different way to think about teaching. It means that individual features make sense only in terms of how they relate with others that surround them. It means that most individual features, by themselves, are not good or bad. Their value depends on how they connect with others and fit into the lesson.

One lesson we described briefly in Chapter 3 began with pure memorization. The teacher asked students to recite three properties they had learned already about parallelograms, such as "opposite sides are parallel and of equal length." Individual

note: these pages are from Chapter **6,**
"Teachingis a Cultural Activity," the substance of which was published before the book in an article that is now on the Web at
http://www.aft.org/american_educator/winter98/TeachingWinter98.pdf

Let's return to the example of the chalkboard versus the overhead projector. Recall that many teachers in the United States have replaced the chalkboard with the overhead projector, whereas Japanese teachers have not. In Chapter 5 we explained this difference in terms of the different instructional systems in which the visual aids are used. In U.S. classrooms visual aids function to guide and control students' attention. Seen in this light, the overhead projector is preferred because it gives teachers even more control over what students are attending to. Within the Japanese system of teaching, visual aids serve a different function. They are not used to control attention but to provide a cumulative record of the lesson's activities and their results. Japanese teachers do not use the overhead projector because it is not possible to fit the cumulative record on an overhead transparency.

To dig deeper we must ask why Japanese teachers want a cumulative record of the lesson to be available to students and why U.S. teachers want to control students' attention. To answer these questions we need to situate these two systems of teaching in the context of cultural beliefs about how students learn and about the role the teacher can play in this process.

Cultural Beliefs About Teaching and Learning: Japan and the United States

As we pursue deeper comparisons of teaching, we focus on Japan and the United States because this comparison is the most

dramatic, and therefore illustrates well the role that beliefs can play in generating and maintaining cultural scripts for teaching.

Nature of Mathematics

The typical U.S. lesson is consistent with the belief that school mathematics is a set of procedures. Although teachers might understand that other things must be added to these procedures to get the complete definition of mathematics, many ***behave*** as if mathematics is a subject whose use for students, in the end, is as a set of procedures for solving problems.

In our study, teachers were asked what "main thing" they wanted students to learn from the lesson. Sixty-one percent of U.S. teachers described ***skills*** they wanted their students to learn. They wanted the students to be able to perform a procedure, solve a particular kind of problem, and so on.

Many U.S. teachers also seem to believe that learning terms and practicing skills is not very exciting. We have watched them trying to jazz up the lesson and increase students' interest in nonmathematical ways: by being entertaining, by interrupting the lesson to talk about other things (last night's local rock concert, for example), or by setting the mathematics problem in a real-life or intriguing context—for example, measuring the circumference of a basketball. Teachers act as if student interest will be generated only by diversions outside of mathematics.

Japanese lessons appear to be generated by different beliefs about the subject. Teachers act as if mathematics is a set of relationships between concepts, facts, and procedures. These relationships are revealed by developing solution methods to problems, studying the methods, working toward increasingly efficient methods, and talking explicitly about the relationships of interest.

On the same questionnaire, 73 percent of Japanese teachers

said that the main thing they wanted their students to learn from the lesson was to think about things in a new way, such as to see new relationships between mathematical ideas.

Japanese teachers also act as if mathematics is inherently interesting and students will be interested in exploring it by developing new methods for solving problems. They seem less concerned about motivating the topics in nonmathematical ways.

Nature of Learning

If one believes that mathematics is mostly a set of procedures and the goal is to help students become proficient executors of the procedures, as many U.S. teachers seem to, then it would be understandable to believe that mathematics is learned best by mastering the material incrementally, piece by piece. This view of skill learning has a long history in the United States.[3] Learning procedures occurs by practicing them many times, with later exercises being slightly more difficult than earlier ones. Practice should be relatively error-free, with high levels of success at each point. Confusion and frustration, in this traditional American view, should be minimized; they are signs that earlier material was not mastered. The more exercises, the more smoothly learning will proceed.

Suppose students are studying how to add and subtract fractions with unlike denominators, such as $\frac{2}{3} + \frac{4}{7}$. The U.S. beliefs about learning described above would dictate that students should first master adding fractions with like denominators, such as $\frac{1}{5} + \frac{2}{5}$, then be shown how to add simple fractions with unlike denominators, such as $\frac{1}{2} + \frac{1}{4}$, being warned about the common error of adding the denominators (to minimize this error), and later practice more difficult problems, such as $\frac{2}{3} + \frac{4}{7}$.

Japanese teachers appear to hold a different set of beliefs about learning and probably would plan a different kind of lesson for adding fractions. One can infer that Japanese teachers believe students learn best by first struggling to solve mathematics problems, then participating in discussions about how to solve them, and then hearing about the pros and cons of different methods and the relationships between them. Frustration and confusion are taken to be a natural part of the process, because each person must struggle with a situation or problem first in order to make sense of the information he or she hears later. Constructing connections between methods and problems is thought to require time to explore and invent, to make mistakes, to reflect, and to receive the needed information at an appropriate time.[4]

What kind of lesson on adding and subtracting fractions with unlike denominators would these beliefs generate? A teacher's manual in a popular Japanese textbook series gives us a clue.[5] It alerts teachers that the error students are most likely to make is to add the denominators. Students will learn to understand the process more fully, says the manual, if they are allowed to make this mistake and then examine the consequences. Some suggestions are given for how to help students reflect on the inconsistencies they will encounter if they add, for example, $\frac{1}{2}$ and $\frac{1}{4}$, and get $\frac{2}{6}$. Teachers are to begin the lesson with a problem like this and then compare the different methods for solution that students develop. Obviously, struggling and making mistakes and then seeing why they are mistakes are believed to be essential parts of the learning process in Japan.

Role of the Teacher

Given the differences between the United States and Japan in the apparent beliefs about the subject and learning, it is not surprising that marked differences can be inferred regarding beliefs

about the role of the teacher. U.S. teachers appear to feel responsible for shaping the task into pieces that are manageable for most students, providing all the information needed to complete the task and assigning plenty of practice. Providing sufficient information means, in many cases, demonstrating how to complete a task just like those assigned for practice. Teachers act as if confusion and frustration are signs that they have not done their job. When they notice confusion, they quickly assist students by providing whatever information it takes to get the students back on track.

We saw the following sequence of events over and over. Teachers assign students seatwork problems and circulate around the room, tutoring and monitoring students' progress. Several students ask, in quick succession, about the same problem. Teachers interrupt the class and say, for example, "Number twenty-three may be a little confusing. Remember to put all the x-terms on one side of the equation and all the y-terms on the other, and then solve fory. That should give the answer." In Mr. Jones's lesson (presented in Chapter 3), these problems were numbers **37** and **38,** and as soon as he sensed that the students had reached them during their seatwork and were struggling, he stepped in to show the solutions. Teachers in the United States try hard to reduce confusion by presenting full information about how to solve problems.

U.S. teachers also take responsibility for keeping students engaged and attending. Given their beliefs about the nature of mathematics and how it **is** learned, moment-by-moment attention is crucial. If students are watching the teacher demonstrate a procedure, they need to attend to each step. If their attention wanders, they will be lost when they try to execute the procedure on their own. Now we have a deeper explanation for the frequent use of the overhead projector by **U.S.** teachers. The projector's capability of focusing attention fits well with the teachers' beliefs about teaching mathematics.

In addition to the use of overhead projectors, **U.S.** teachers use a variety of other techniques to hold students' attention. They pump up students' interest by increasing the pace of the activities, by praising students for their work and behavior, by the cuteness or real-lifeness of tasks, and by their own power of persuasion through their enthusiasm, humor, and "coolness."

Japanese teachers apparently believe they are responsible for different aspects of classroom activity. They often choose a challenging problem to begin the lesson, and they help students understand and represent the problem **so** they can begin working on a solution. While students are working, the teachers monitor their solution methods so they can organize the follow-up discussion when students share solutions. They also encourage students to keep struggling in the face of difficulty, sometimes offering hints to support students' progress. Rarely would teachers show students how to solve the problem midway through the lesson.

Japanese teachers lead class discussions, asking questions about the solution methods presented, pointing out important features of students' methods, and presenting methods themselves. Because they seem to believe that learning mathematics means constructing relationships between facts, procedures, and ideas, they try to create a visual record of these different methods as the lesson proceeds. Apparently, it is not as important for students to attend at each moment of the lesson as it is for them to be able to go back and think again about earlier events, and to see connections between the different parts of the lesson. Now we understand why Japanese teachers prefer the chalkboard to the overhead projector. Indeed, now we see, in a deeper way, why they cannot use the projector.