

## CHAPTER EIGHT

*Rice Paddies and  
Math Tests*

"NO ONE WHO CAN RISE BEFORE DAWN  
THREE HUNDRED SIXTY DAYS A YEAR  
FAILS TO MAKE HIS FAMILY RICH."

## 1.

The gateway to the industrial heartland of Southern China runs up through the wide, verdant swath of the Pearl River Delta. The land is covered by a thick, smoggy haze. The freeways are crammed with tractor trailers. Power lines crisscross the landscape. Factories making cameras, computers, watches, umbrellas, and T-shirts stand cheek by jowl with densely packed blocks of apartment buildings and fields of banana and mango trees, sugarcane, papaya, and pineapple destined for the export market. Few landscapes in the world have changed so much in so short a time.

A generation ago, the skies would have been clear and the road would have been a two-lane highway. And a generation before that, all you would have seen were rice paddies.

Two hours in, at the headwaters of the Pearl River, lies the city of Guangzhou, and past Guangzhou, remnants of the old China are easier to find. The countryside becomes breathtakingly beautiful, rolling hills dotted with outcroppings of limestone rock against the backdrop of the Nan Ling Mountains. Here and there are the traditional khaki-colored mud-brick huts of the Chinese peasantry. In the small towns, there are open-air markets: chickens and geese in elaborate bamboo baskets, vegetables laid out in rows on the ground, slabs of pork on tables, tobacco being sold in big clumps. And everywhere, there is rice, miles upon miles of it. In the winter season, the paddies are dry and dotted with the stubble of the previous year's crop. After the crops are planted in early spring, as the humid winds begin to blow, they turn a magical green, and by the time of the first harvest, as the grains emerge on the ends of the rice shoots, the land becomes an unending sea of yellow.

Rice has been cultivated in China for thousands of years. It was from China that the techniques of rice cultivation spread throughout East Asia—Japan, Korea, Singapore, and Taiwan. Year in, year out, as far back as history is recorded, farmers from across

Asia have engaged in the same relentless, intricate pattern of agriculture.

Rice paddies are "built," not "opened up" the way a wheat field is. You don't just clear the trees, underbrush, and stones and then plow. Rice fields are carved into mountainsides in an elaborate series of terraces, or painstakingly constructed from marshland and river plains. A rice paddy has to be irrigated, so a complex system of dikes has to be built around the field. Channels must be dug from the nearest water source, and gates built into the dikes so the water flow can be adjusted precisely to cover the right amount of the plant.

The paddy itself, meanwhile, has to have a hard clay floor; otherwise the water will simply seep into the ground. But of course, rice seedlings can't be planted in hard clay, so on top of the clay, there has to be a thick, soft layer of mud. And the claypan, as it's called, has to be carefully engineered so that it will drain properly and also keep the plants submerged at the optimum level. Rice has to be fertilized repeatedly, which is another art. Traditionally, farmers used "night soil" (human manure) and a combination of burned compost, river mud, bean cake, and hemp—and they had to be careful, because too much fertilizer, or the right amount applied at the wrong time, could be as bad as too little.

When the time came to plant, a Chinese farmer

would have hundreds of different varieties of rice from which to choose, each one of which offered a slightly different trade-off, say, between yield and how quickly it grew, or how well it did in times of drought, or how it fared in poor soil. A farmer might plant a dozen or more different varieties at one time, adjusting the mix from season to season in order to manage the risk of a crop failure.

He or she (or, more accurately, the whole family, since rice agriculture was a family affair) would plant the seed in a specially prepared seedbed. After a few weeks, the seedlings would be transplanted into the field, in carefully spaced rows six inches apart, and then painstakingly nurtured.

Weeding was done by hand, diligently and unceasingly, because the seedlings could easily be choked by other plant life. Sometimes each rice shoot would be individually groomed with a bamboo comb to clear away insects. All the while, farmers had to check and recheck water levels and make sure the water didn't get too hot in the summer sun. And when the rice ripened, farmers gathered all of their friends and relatives and, in one coordinated burst, harvested it as quickly as possible so they could get a second crop in before the winter dry season began.

Breakfast in South China, at least for those who could afford it, was congee—white rice porridge with lettuce and dace paste and bamboo shoots. Lunch

was more congee. Dinner was rice with “toppings.” Rice was what you sold at the market to buy the other necessities of life. It was how wealth and status were measured. It dictated almost every working moment of every day. “Rice is life,” says the anthropologist Gonçalo Santos, who has studied a traditional South Chinese village. “Without rice, you don’t survive. If you want to be anyone in this part of China, you would have to have rice. It made the world go around.”

## 2.

Take a look at the following list of numbers: 4, 8, 5, 3, 9, 7, 6. Read them out loud. Now look away and spend twenty seconds memorizing that sequence before saying them out loud again.

If you speak English, you have about a 50 percent chance of remembering that sequence perfectly. If you’re Chinese, though, you’re almost certain to get it right every time. Why is that? Because as human beings we store digits in a memory loop that runs for about two seconds. We most easily memorize whatever we can say or read within that two-second span. And Chinese speakers get that list of numbers—4, 8, 5, 3, 9, 7, 6—right almost every time because, unlike English, their language allows them to fit all those seven numbers into two seconds.

That example comes from Stanislas Dehaene’s book *The Number Sense*. As Dehaene explains:

Chinese number words are remarkably brief. Most of them can be uttered in less than one-quarter of a second (for instance, 4 is “si” and 7 “qi”). Their English equivalents—“four,” “seven”—are longer: pronouncing them takes about one-third of a second. The memory gap between English and Chinese apparently is entirely due to this difference in length. In languages as diverse as Welsh, Arabic, Chinese, English and Hebrew, there is a reproducible correlation between the time required to pronounce numbers in a given language and the memory span of its speakers. In this domain, the prize for efficacy goes to the Cantonese dialect of Chinese, whose brevity grants residents of Hong Kong a rocketing memory span of about 10 digits.

It turns out that there is also a big difference in how number-naming systems in Western and Asian languages are constructed. In English, we say fourteen, sixteen, seventeen, eighteen, and nineteen, so one might expect that we would also say oneteen, twoteen, threeteen, and fiveteen. But we don’t. We use a different form: eleven, twelve, thirteen, and fifteen. Similarly, we have forty and sixty, which sound like the words they are related to (four and six). But we also say fifty and thirty and twenty, which sort

of sound like five and three and two, but not really. And, for that matter, for numbers above twenty, we put the "decade" first and the unit number second (twenty-one, twenty-two), whereas for the teens, we do it the other way around (fourteen, seventeen, eighteen). The number system in English is highly irregular. Not so in China, Japan, and Korea. They have a logical counting system. Eleven is ten-one. Twelve is ten-two. Twenty-four is two-tens-four and so on.

That difference means that Asian children learn to count much faster than American children. Four-year-old Chinese children can count, on average, to forty. American children at that age can count only to fifteen, and most don't reach forty until they're five. By the age of five, in other words, American children are already a *year* behind their Asian counterparts in the most fundamental of math skills.

The regularity of their number system also means that Asian children can perform basic functions, such as addition, far more easily. Ask an English-speaking seven-year-old to add thirty-seven plus twenty-two in her head, and she has to convert the words to numbers ( $37 + 22$ ). Only then can she do the math: 2 plus 7 is 9 and 30 and 20 is 50, which makes 59. Ask an Asian child to add three-tens-seven and two-tens-two, and then the necessary equation is right there, embedded in the sentence. No number translation is necessary: It's five-tens-nine.

"The Asian system is transparent," says Karen Fuson, a Northwestern University psychologist who has closely studied Asian-Western differences. "I think that it makes the whole attitude toward math different. Instead of being a rote learning thing, there's a pattern I can figure out. There is an expectation that I can do this. There is an expectation that it's sensible. For fractions, we say three-fifths. The Chinese is literally 'out of five parts, take three.' That's telling you conceptually what a fraction is. It's differentiating the denominator and the numerator."

The much-storied disenchantment with mathematics among Western children starts in the third and fourth grades, and Fuson argues that perhaps a part of that disenchantment is due to the fact that math doesn't seem to make sense; its linguistic structure is clumsy; its basic rules seem arbitrary and complicated.

Asian children, by contrast, don't feel nearly that same bafflement. They can hold more numbers in their heads and do calculations faster, and the way fractions are expressed in their languages corresponds exactly to the way a fraction actually is—and maybe that makes them a little more likely to enjoy math, and maybe because they enjoy math a little more, they try a little harder and take more math classes and are more willing to do their homework, and on and on, in a kind of virtuous circle.

When it comes to math, in other words, Asians

have a built-in advantage. But it's an unusual kind of advantage. For years, students from China, South Korea, and Japan—and the children of recent immigrants who are from those countries—have substantially outperformed their Western counterparts at mathematics, and the typical assumption is that it has something to do with a kind of innate Asian proclivity for math.\* The psychologist Richard Lynn has even gone so far as to propose an elaborate evolutionary theory involving the Himalayas, really cold weather, premodern hunting practices, brain size, and specialized vowel sounds to explain why Asians have higher IQs.† That's how we think about math. We assume that being good at things like calculus and algebra is

\* On international comparison tests, students from Japan, South Korea, Hong Kong, Singapore, and Taiwan all score roughly the same in math, around the ninety-eighth percentile. The United States, France, England, Germany, and the other Western industrialized nations cluster at somewhere between the twenty-six and thirty-sixth percentile. That's a big difference.

† Lynn's claim that Asians have higher IQs has been refuted, convincingly, by a number of other experts, who showed that he based his argument on IQ samples drawn disproportionately from urban, upper-income homes. James Flynn, perhaps the world's leading expert on IQ, has subsequently made a fascinating counterclaim. Asians' IQs, he says, have historically been slightly lower than whites' IQs, meaning that their dominance in math has been in spite of their IQ, not because of it. Flynn's argument was outlined in his book *Asian Americans: Achievement Beyond IQ* (1991).

a simple function of how smart someone is. But the differences between the number systems in the East and the West suggest something very different—that being good at math may also be rooted in a group's *culture*.

In the case of the Koreans, one kind of deeply rooted legacy stood in the way of the very modern task of flying an airplane. Here we have another kind of legacy, one that turns out to be perfectly suited for twenty-first-century tasks. Cultural legacies *matter*, and once we've seen the surprising effects of such things as power distance and numbers that can be said in a quarter as opposed to a third of a second, it's hard not to wonder how many other cultural legacies have an impact on our twenty-first-century intellectual tasks. What if coming from a culture shaped by the demands of growing rice also makes you better at math? Could the rice paddy make a difference in the classroom?

### 3.

The most striking fact about a rice paddy—which can never quite be grasped until you actually stand in the middle of one—is its size. It's *tiny*. The typical rice paddy is about as big as a hotel room. A typical Asian rice farm might be composed of two or three paddies. A village in China of fifteen hundred people might

support itself entirely with 450 acres of land, which in the American Midwest would be the size of a typical family farm. At that scale, with families of five and six people living off a farm the size of two hotel rooms, agriculture changes dramatically.

Historically, Western agriculture is “mechanically” oriented. In the West, if a farmer wanted to become more efficient or increase his yield, he introduced more and more sophisticated equipment, which allowed him to replace human labor with mechanical labor: a threshing machine, a hay baler, a combine harvester, a tractor. He cleared another field and increased his acreage, because now his machinery allowed him to work more land with the same amount of effort. But in Japan or China, farmers didn’t have the money to buy equipment—and, in any case, there certainly wasn’t any extra land that could easily be converted into new fields. So rice farmers improved their yields by becoming smarter, by being better managers of their own time, and by making better choices. As the anthropologist Francesca Bray puts it, rice agriculture is “skill oriented”: if you’re willing to weed a bit more diligently, and become more adept at fertilizing, and spend a bit more time monitoring water levels, and do a better job keeping the claypan absolutely level, and make use of every square inch of your rice paddy, you’ll harvest a bigger crop. Throughout history, not surprisingly, the people who grow rice have

always worked harder than almost any other kind of farmer.

That last statement may seem a little odd, because most of us have a sense that everyone in the premodern world worked really hard. But that simply isn’t true. All of us, for example, are descended at some point from hunter-gatherers, and many hunter-gatherers, by all accounts, had a pretty leisurely life. The !Kung bushmen of the Kalahari Desert, in Botswana, who are one of the last remaining practitioners of that way of life, subsist on a rich assortment of fruits, berries, roots, and nuts—in particular the mongongo nut, an incredibly plentiful and protein-rich source of food that lies thick on the ground. They don’t grow anything, and it is growing things—preparing, planting, weeding, harvesting, storing—that takes time. Nor do they raise any animals. Occasionally, the male !Kung hunt, but chiefly for sport. All told, !Kung men and women work no more than about twelve to nineteen hours a week, with the balance of the time spent dancing, entertaining, and visiting family and friends. That’s, at most, one thousand hours of work a year. (When a bushman was asked once why his people hadn’t taken to agriculture, he looked puzzled and said, “Why should we plant, when there are so many mongongo nuts in the world?”)

Or consider the life of a peasant in eighteenth-century Europe. Men and women in those days

probably worked from dawn to noon two hundred days a year, which works out to about twelve hundred hours of work annually. During harvest or spring planting, the day might be longer. In the winter, much less. In *The Discovery of France*, the historian Graham Robb argues that peasant life in a country like France, even well into the nineteenth century, was essentially brief episodes of work followed by long periods of idleness.

"Ninety-nine percent of all human activity described in this and other accounts [of French country life]," he writes, "took place between late spring and early autumn." In the Pyrenees and the Alps, entire villages would essentially hibernate from the time of the first snow in November until March or April. In more temperate regions of France, where temperatures in the winter rarely fell below freezing, the same pattern held. Robb continues:

The fields of Flanders were deserted for much of the year. An official report on the Nièvre in 1844 described the strange mutation of the Burgundian day-laborer once the harvest was in and the vine stocks had been burned: "After making the necessary repairs to their tools, these vigorous men will now spend their days in bed, packing their bodies tightly together in order to stay warm and eat less food. They weaken themselves deliberately."

Human hibernation was a physical and economic necessity. Lowering the metabolic rate prevented hunger from exhausting supplies.... People trudged and dawdled, even in summer.... After the revolution, in Alsace and the Pas-de-Calais, officials complained that wine growers and independent farmers, instead of undertaking "some peaceful and sedentary industry" in the quieter season, "abandon themselves to dumb idleness."

If you were a peasant farmer in Southern China, by contrast, you didn't sleep through the winter. In the short break marked by the dry season, from November through February, you busied yourself with side tasks. You made bamboo baskets or hats and sold them in the market. You repaired the dikes in your rice paddy, and rebuilt your mud hut. You sent one of your sons to work in a nearby village for a relative. You made tofu and dried bean curd and caught snakes (they were a delicacy) and trapped insects. By the time *lahp cheun* (the "turning of the spring") came, you were back in the fields at dawn. Working in a rice field is ten to twenty times more labor-intensive than working on an equivalent-size corn or wheat field. Some estimates put the annual workload of a wet-rice farmer in Asia at *three thousand* hours a year.

## 4.

Think, for a moment, about what the life of a rice farmer in the Pearl River Delta must have been like. Three thousand hours a year is a staggering amount of time to spend working, particularly if many of those hours involve being bent over in the hot sun, planting and weeding in a rice paddy.

What redeemed the life of a rice farmer, however, was the nature of that work. It was a lot like the garment work done by the Jewish immigrants to New York. It was *meaningful*. First of all, there is a clear relationship in rice farming between effort and reward. The harder you work a rice field, the more it yields. Second, it's complex work. The rice farmer isn't simply planting in the spring and harvesting in the fall. He or she effectively runs a small business, juggling a family workforce, hedging uncertainty through seed selection, building and managing a sophisticated irrigation system, and coordinating the complicated process of harvesting the first crop while simultaneously preparing the second crop.

And, most of all, it's autonomous. The peasants of Europe worked essentially as low-paid slaves of an aristocratic landlord, with little control over their own destinies. But China and Japan never developed that kind of oppressive feudal system, because

feudalism simply can't work in a rice economy. Growing rice is too complicated and intricate for a system that requires farmers to be coerced and bullied into going out into the fields each morning. By the fourteenth and fifteenth centuries, landlords in central and Southern China had an almost completely hands-off relationship with their tenants: they would collect a fixed rent and let farmers go about their business.

"The thing about wet-rice farming is, not only do you need phenomenal amounts of labor, but it's very exacting," says the historian Kenneth Pomerantz. "You have to care. It really matters that the field is perfectly leveled before you flood it. Getting it close to level but not quite right makes a big difference in terms of your yield. It really matters that the water is in the fields for just the right amount of time. There's a big difference between lining up the seedlings at exactly the right distance and doing it sloppily. It's not like you put the corn in the ground in mid-March and as long as rain comes by the end of the month, you're okay. You're controlling all the inputs in a very direct way. And when you have something that requires that much care, the overlord has to have a system that gives the actual laborer some set of incentives, where if the harvest comes out well, the farmer gets a bigger share. That's why you get fixed rents, where the landlord says, I get twenty bushels, regardless of the harvest, and if it's really good, you get the extra. It's a crop that

doesn't do very well with something like slavery or wage labor. It would just be too easy to leave the gate that controls the irrigation water open a few seconds too long and there goes your field."

The historian David Arkush once compared Russian and Chinese peasant proverbs, and the differences are striking. "If God does not bring it, the earth will not give it" is a typical Russian proverb. That's the kind of fatalism and pessimism typical of a repressive feudal system, where peasants have no reason to believe in the efficacy of their own work. On the other hand, Arkush writes, Chinese proverbs are striking in their belief that "hard work, shrewd planning and self-reliance or cooperation with a small group will in time bring recompense."

Here are some of the things that penniless peasants would say to one another as they worked three thousand hours a year in the baking heat and humidity of Chinese rice paddies (which, by the way, are filled with leeches):

"No food without blood and sweat."

"Farmers are busy; farmers are busy; if farmers weren't busy, where would grain to get through the winter come from?"

"In winter, the lazy man freezes to death."

"Don't depend on heaven for food, but on your own two hands carrying the load."

"Useless to ask about the crops, it all depends on hard work and fertilizer."

"If a man works hard, the land will not be lazy."

And, most telling of all: "No one who can rise before dawn three hundred sixty days a year fails to make his family rich." *Rise before dawn? 360 days a year?* For the !Kung leisurely gathering mongongo nuts, or the French peasant sleeping away the winter, or anyone else living in something other than the world of rice cultivation, that proverb would be unthinkable.

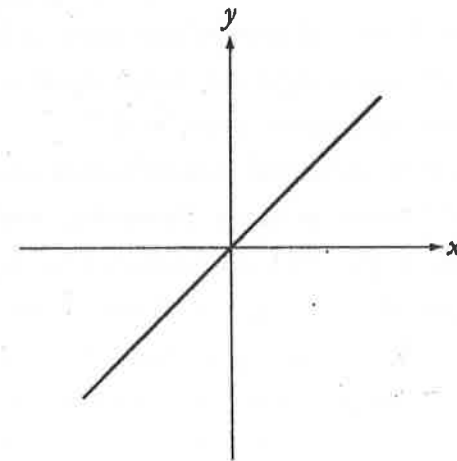
This is not, of course, an unfamiliar observation about Asian culture. Go to any Western college campus and you'll find that Asian students have a reputation for being in the library long after everyone else has left. Sometimes people of Asian background get offended when their culture is described this way, because they think that the stereotype is being used as a form of disparagement. But a belief in work ought to be a thing of beauty. Virtually every success story we've seen in this book so far involves someone or some group working harder than their peers. Bill Gates was addicted to his computer as a child. So was Bill Joy. The Beatles put in thousands of hours of practice in Hamburg. Joe Flom ground away for years, perfecting the art of takeovers, before he got his

chance. Working really hard is what successful people do, and the genius of the culture formed in the rice paddies is that hard work gave those in the fields a way to find meaning in the midst of great uncertainty and poverty. That lesson has served Asians well in many endeavors but rarely so perfectly as in the case of mathematics.

5.

A few years ago, Alan Schoenfeld, a math professor at Berkeley, made a videotape of a woman named Renee as she was trying to solve a math problem. Renee was in her mid-twenties, with long black hair and round silver glasses. In the tape, she's playing with a software program designed to teach algebra. On the screen are a  $y$  and an  $x$  axis. The program asks the user to punch in a set of coordinates and then draws the line from those coordinates on the screen. For example, when she typed in 5 on the  $y$  axis and 5 on the  $x$  axis, the computer did this: See following graph on page 281.

At this point, I'm sure, some vague memory of your middle-school algebra is coming back to you. But rest assured, you don't need to remember any of it to understand the significance of Renee's example. In fact, as you listen to Renee talking in the next few paragraphs, focus not on what she's saying but rather



on how she's talking and why she's talking the way she is.

The point of the computer program, which Schoenfeld created, was to teach students about how to calculate the slope of a line. Slope, as I'm sure you remember (or, more accurately, as I'll bet you don't remember; I certainly didn't), is rise over run. The slope of the line in our example is 1, since the rise is 5 and the run is 5.

So there is Renee. She's sitting at the keyboard, and she's trying to figure out what numbers to enter in order to get the computer to draw a line that is absolutely vertical, that is directly superimposed over the  $y$  axis. Now, those of you who remember your high school math will know that this is, in fact, impossible. A vertical line has an undefined slope. Its rise is

infinite: any number on the  $y$  axis starting at zero and going on forever. It's run on the  $x$  axis, meanwhile, is zero. Infinity divided by zero is not a number.

But Renee doesn't realize that what she's trying to do can't be done. She is, rather, in the grip of what Schoenfeld calls a "glorious misconception," and the reason Schoenfeld likes to show this particular tape is that it is a perfect demonstration of how this misconception came to be resolved.

Renee was a nurse. She wasn't someone who had been particularly interested in mathematics in the past. But she had somehow gotten hold of the software and was hooked.

"Now, what I want to do is make a straight line with this formula, parallel to the  $y$  axis," she begins. Schoenfeld is sitting next to her. She looks over at him anxiously. "It's been five years since I did any of this."

She starts to fiddle with the program, typing in different numbers:

"Now if I change the slope that way...minus 1...now what I mean to do is make the line go straight."

As she types in numbers, the line on the screen changes.

"Oops. That's not going to do it."

She looks puzzled.

"What are you trying to do?" Schoenfeld asks.

"What I'm trying to do is make a straight line parallel to the  $y$  axis. What do I need to do here? I think

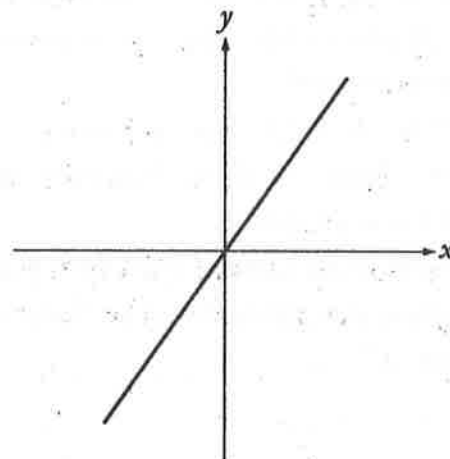
what I need to do is change this a little bit." She points at the place where the number for the  $y$  axis is. "That was something I discovered. That when you go from 1 to 2, there was a rather big change. But now if you get way up there you have to keep changing."

This is Renee's glorious misconception. She's noticed the higher she makes the  $y$  axis coordinate, the steeper the line gets. So she thinks the key to making a vertical line is just making the  $y$  axis coordinate large enough.

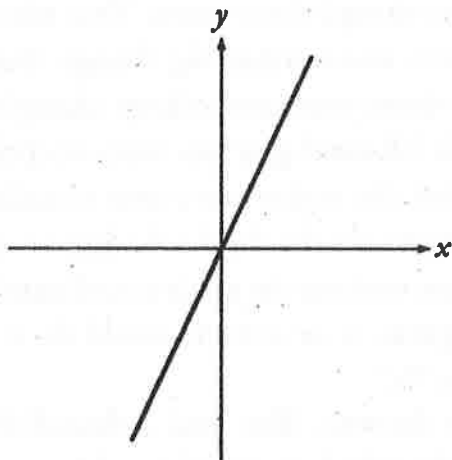
"I guess 12 or even 13 could do it. Maybe even as much as 15."

She frowns. She and Schoenfeld go back and forth. She asks him questions. He prods her gently in the right direction. She keeps trying and trying, one approach after another.

At one point, she types in 20. The line gets a little bit steeper.



She types in 40. The line gets steeper still.



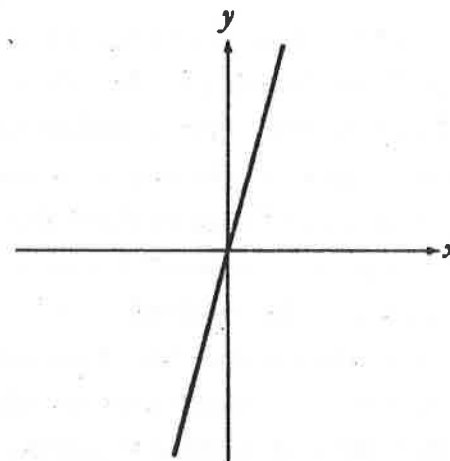
"I see that there is a relationship there. But as to why, it doesn't seem to make sense to me.... What if I do 80? If 40 gets me halfway, then 80 should get me all the way to the  $y$  axis. So let's just see what happens."

She types in 80. The line is steeper. But it's still not totally vertical.

"Ohhh. It's infinity, isn't it? It's never going to get there." Renee is close. But then she reverts to her original misconception.

"So what do I need? 100? Every time you double the number, you get halfway to the  $y$  axis. But it never gets there..."

She types in 100.



"It's closer. But not quite there yet."

She starts to think out loud. It's obvious she's on the verge of figuring something out. "Well, I knew this, though...but...I knew that. For each one up, it goes that many over. I'm still somewhat confused as to why..."

She pauses, squinting at the screen.

"I'm getting confused. It's a tenth of the way to the one. But I don't want it to be..."

And then she sees it.

"Oh! It's any number up, and zero over. It's any number divided by zero!" Her face lights up. "A vertical line is anything divided by zero—and that's an undefined number. Ohhh. Okay. Now I see. The slope of a vertical line is undefined. Ahhhh. That means something now. I won't forget that!"

## 6.

Over the course of his career, Schoenfeld has videotaped countless students as they worked on math problems. But the Renee tape is one of his favorites because of how beautifully it illustrates what he considers to be the secret to learning mathematics. *Twenty-two minutes* pass from the moment Renee begins playing with the computer program to the moment she says, "Ahhhh. That means something now." That's a *long* time. "This is eighth-grade mathematics," Schoenfeld said. "If I put the average eighth grader in the same position as Renee, I'm guessing that after the first few attempts, they would have said, 'I don't get it. I need you to explain it.'" Schoenfeld once asked a group of high school students how long they would work on a homework question before they concluded it was too hard for them ever to solve. Their answers ranged from thirty seconds to five minutes, with the average answer two minutes.

But Renee persists. She experiments. She goes back over the same issues time and again. She thinks out loud. She keeps going and going. She simply won't give up. She knows on some vague level that there is something wrong with her theory about how to draw a vertical line, and she won't stop until she's absolutely sure she has it right.

Renee wasn't a math natural. Abstract concepts like "slope" and "undefined" clearly didn't come easily to her. But Schoenfeld could not have found her more impressive.

"There's a will to make sense that drives what she does," Schoenfeld says. "She wouldn't accept a superficial 'Yeah, you're right' and walk away. That's not who she is. And that's really unusual." He rewound the tape and pointed to a moment when Renee reacted with genuine surprise to something on the screen.

"Look," he said. "She does a double take. Many students would just let that fly by. Instead, she thought, 'That doesn't jibe with whatever I'm thinking. I don't get it. That's important. I want an explanation.' And when she finally gets the explanation, she says, 'Yeah, that fits.'"

At Berkeley, Schoenfeld teaches a course on problem solving, the entire point of which, he says, is to get his students to unlearn the mathematical habits they picked up on the way to university. "I pick a problem that I don't know how to solve," he says. "I tell my students, 'You're going to have a two-week take-home exam. I know your habits. You're going to do nothing for the first week and start it next week, and I want to warn you now: If you only spend one week on this, you're not going to solve it. If, on the other hand, you start working the day I give you

the midterm, you'll be frustrated. You'll come to me and say, 'It's impossible.' I'll tell you, Keep working, and by week two, you'll find you'll make significant progress."

We sometimes think of being good at mathematics as an innate ability. You either have "it" or you don't. But to Schoenfeld, it's not so much ability as *attitude*. You master mathematics if you are willing to try. That's what Schoenfeld attempts to teach his students. Success is a function of persistence and doggedness and the willingness to work hard for twenty-two minutes to make sense of something that most people would give up on after thirty seconds. Put a bunch of Renees in a classroom, and give them the space and time to explore mathematics for themselves, and you could go a long way. Or imagine a country where Renee's doggedness is not the exception, but a cultural trait, embedded as deeply as the culture of honor in the Cumberland Plateau. Now that would be a country good at math.

## 7.

Every four years, an international group of educators administers a comprehensive mathematics and science test to elementary and junior high students around the world. It's the TIMSS (the same test you read about earlier, in the discussion of differences

between fourth graders born near the beginning of a school cutoff date and those born near the end of the date), and the point of the TIMSS is to compare the educational achievement of one country with another's.

When students sit down to take the TIMSS exam, they also have to fill out a questionnaire. It asks them all kinds of things, such as what their parents' level of education is, and what their views about math are, and what their friends are like. It's not a trivial exercise. It's about 120 questions long. In fact, it is so tedious and demanding that many students leave as many as ten or twenty questions blank.

Now, here's the interesting part. As it turns out, the average number of items answered on that questionnaire varies from country to country. It is possible, in fact, to rank all the participating countries according to how many items their students answer on the questionnaire. Now, what do you think happens if you compare the questionnaire rankings with the math rankings on the TIMSS? *They are exactly the same.* In other words, countries whose students are willing to concentrate and sit still long enough and focus on answering every single question in an endless questionnaire are the same countries whose students do the best job of solving math problems.

The person who discovered this fact is an edu-

cational researcher at the University of Pennsylvania named Erling Boe, and he stumbled across it by accident. "It came out of the blue," he says. Boe hasn't even been able to publish his findings in a scientific journal, because, he says, it's just a bit too weird. Remember, he's not saying that the ability to finish the questionnaire and the ability to excel on the math test are related. He's saying that they are *the same*: if you compare the two rankings, they are identical.

Think about this another way. Imagine that every year, there was a Math Olympics in some fabulous city in the world. And every country in the world sent its own team of one thousand eighth graders. Boe's point is that we could predict precisely the order in which every country would finish in the Math Olympics *without asking a single math question*. All we would have to do is give them some task measuring how hard they were willing to work. In fact, we wouldn't even have to give them a task. We should be able to predict which countries are best at math simply by looking at which national cultures place the highest emphasis on effort and hard work.

So, which places are at the top of both lists? The answer shouldn't surprise you: Singapore, South Korea, China (Taiwan), Hong Kong, and Japan. What those five have in common, of course, is that they are all cultures shaped by the tradition of wet-rice

agriculture and meaningful work.\* They are the kinds of places where, for hundreds of years, penniless peasants, slaving away in the rice paddies three thousand hours a year, said things to one another like "No one who can rise before dawn three hundred sixty days a year fails to make his family rich."†

\* Two small points. Mainland China isn't on this list because China doesn't yet take part in the TIMSS study. But the fact that Taiwan and Hong Kong rank so highly suggests that the mainland would probably also do really well.

Second, and perhaps more important, what happens in the north of China, which isn't a wet-rice agriculture society but historically a wheat-growing culture, much like Western Europe? Are they good at math too? The short answer is that we don't know. The psychologist James Flynn points out, though, that the overwhelming majority of Chinese immigrants to the West—the people who have done so well in math here—are from South China. The Chinese students graduating at the top of their class at MIT are the descendants, chiefly, of people from the Pearl River Delta. He also points out that the lowest-achieving Chinese Americans are the so-called Sze Yap people, who come from the edges of the Delta, "where soil was less fertile and agriculture less intense."

† There is actually a significant scientific literature measuring Asian "persistence." In a typical study, Priscilla Blinco gave large groups of Japanese and American first graders a very difficult puzzle and measured how long they worked at it before they gave up. The American children lasted, on average, 9.47 minutes. The Japanese children lasted 13.93 minutes, roughly 40 percent longer.

