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Building a Better Teacher

By ELIZABETH GREEN

ON A WINTER DAY five years ago, Doug Lemov realized he had a problem. After a successful career as a teacher, a principal and a charter-school founder, he was working as a consultant, hired by troubled schools eager — desperate, in some cases — for Lemov to tell them what to do to get better. There was no shortage of prescriptions at the time for how to cure the poor performance that plagued so many American schools. Proponents of No Child Left Behind saw standardized testing as a solution. President Bush also championed a billion-dollar program to encourage schools to adopt reading curriculums with an emphasis on phonics. Others argued for smaller classes or more parental involvement or more state financing.

Lemov himself pushed for data-driven programs that would diagnose individual students' strengths and weaknesses. But as he went from school to school that winter, he was getting the sinking feeling that there was something deeper he wasn't reaching. On that particular day, he made a depressing visit to a school in Syracuse, N.Y., that was like so many he'd seen before: "a dispiriting exercise in good people failing," as he described it to me recently. Sometimes Lemov could diagnose problems as soon as he walked in the door. But not here. Student test scores had dipped so low that administrators worried the state might close down the school. But the teachers seemed to care about their students. They sat down with them on the floor to read and picked activities that should have engaged them. The classes were small. The school had rigorous academic standards and state-of-the-art curriculums and used a software program to analyze test results for each student, pinpointing which skills she still needed to work on.

But when it came to actual teaching, the daily task of getting students to learn, the school floundered. Students disobeyed teachers' instructions, and class discussions veered away from the lesson plans. In one class Lemov observed, the teacher spent several minutes debating a student about why he didn't have a pencil. Another divided her students into two groups to practice multiplication together, only to watch them turn to the more interesting work of chatting. A single quiet student soldiered on with the problems. As Lemov drove from Syracuse back to his home in Albany, he tried to figure out what he could do to help. He knew how to advise schools to adopt a better curriculum or raise standards or develop better communication channels between teachers and principals. But he realized that he had no clue how to advise schools about their main event: how to teach.

Around the country, education researchers were beginning to address similar questions. The testing mandates in No Child Left Behind had generated a sea of data, and researchers were now able to parse student achievement in ways they never had before. A new generation of economists devised statistical methods to measure the "value added" to a student's performance by almost every factor imaginable: class size versus per-pupil funding versus curriculum. When researchers ran the numbers in dozens of different studies, every factor under a school's control produced just a tiny impact, except for one: which teacher the student had been assigned to. Some teachers could regularly lift their students' test scores above the average for children of the same race, class and ability level. Others' students left with below-average results year after year. William Sanders, a statistician studying Tennessee teachers with a colleague, found that a student with a weak teacher for three straight years would score, on average, 50 percentile points behind a similar student with a strong teacher for those years. Teachers working in the same building, teaching the same grade, produced very different outcomes. And the gaps were huge. Eric Hanushek, a Stanford economist, found that while the top 5 percent of teachers were able to impart a year and a half's worth of learning to students in one school year, as judged by standardized tests, the weakest 5 percent advanced their students only half a year of material each year.

This record encouraged a belief in some people that good teaching must be purely instinctive, a kind of magic performed by born superstars. As Jane Hannaway, the director of the Education Policy Center at the Urban Institute and a former teacher, put it to me, successful teaching depends in part on a certain inimitable "voodoo." You either have it or you don't. "I think that there is an innate drive or innate ability for teaching," Sylvia Gist, the dean of the college of education at Chicago State University, said when I visited her campus last year.

That belief has spawned a nationwide movement to improve the quality of the teaching corps by firing the bad teachers and hiring better ones. "Creating a New Teaching Profession," a new collection of academic papers, politely calls this idea "deselection"; Joel Klein, the New York City schools chancellor, put it more bluntly when he gave a talk in Manhattan recently. "If we don't change the personnel," he said, "all we're doing is changing the chairs."

The reformers are also trying to create incentives to bring what Michelle Rhee, the schools chancellor in Washington, calls a "different caliber of person" into the profession. Rhee has proposed giving cash bonuses to those teachers whose students learn the most, as measured by factors that include standardized tests — and firing those who don't measure up. Under her suggested compensation system, the city's best teachers could earn as much as $130,000 a year. (The average pay for a teacher in Washington is now $65,000.) A new charter school in New York City called the Equity Project offers starting salaries of $125,000. "Merit pay," a once-obscure free-market notion of handing cash bonuses to the best teachers, has lately become a litmus test for seriousness about improving schools. The Obama administration's education department has embraced merit pay; the federal Teacher Incentive Fund, which finances experimental merit-pay

programs across the country, rose from $97 million to $400 million this year. And states interested in competing for a piece of the $4.3 billion discretionary fund called the Race to the Top were required to change their laws to give principals and superintendents the right to judge teachers based on their students' academic performance.

Incentives are intuitively appealing: if a teacher could make real money, maybe more people would choose teaching over finance or engineering or law, expanding the labor pool. And no one wants incompetent teachers in the classroom. Yet so far, both merit-pay efforts and programs that recruit a more-elite teaching corps, like Teach for America, have thin records of reliably improving student learning. Even if competition could coax better performance, would it be enough? Consider a bar graph presented at a recent talk on teaching, displaying the number of Americans in different professions. The shortest bar, all the way on the right, represented architects: 180,000. Farther over, slightly higher, came psychologists (185,000) and then lawyers (952,000), followed by engineers (1.3 million) and waiters (1.8 million). On the left side of the graph, the top three: janitors, maids and household cleaners (3.3 million); secretaries (3.6 million); and, finally, teachers (3.7 million). Moreover, a coming swell of baby-boomer retirements is expected to force school systems to hire up to a million new teachers between now and 2014. Expanding the pool of potential teachers is clearly important, but in a profession as large as teaching, can financial incentives alone make an impact?

Lemov spent his early career putting his faith in market forces, building accountability systems meant to reward high-performing charter schools and force the lower-performing ones to either improve or go out of business. The incentives did shock some schools into recognizing their shortcomings. But most of them were like the one in Syracuse: they knew they had to change, but they didn't know how. "There was an implementation gap," Lemov told me. "Incentives by themselves were not going to be enough." Lemov calls this the Edison Parable, after the for-profit company Edison Schools, which in the 1990s tried to create a group of accountable schools but ultimately failed to outperform even the troubled Cleveland public schools.

Lemov doesn't reject incentives. In fact, at Uncommon Schools, the network of 16 charter schools in the Northeast that he helped found and continues to help run today, he takes performance into account when setting teacher pay. Yet he has come to the conclusion that simply dangling better pay will not improve student performance on its own. And the stakes are too high: while student scores on national assessments across demographic groups have risen, the percentage of students at proficiency — just 39 percent of fourth graders in math and 33 percent in reading — is still disturbingly low. And there is still a wide gap between black and white students in reading and math. The smarter path to boosting student performance, Lemov maintains, is to improve the quality of the teachers who are already teaching.

But what makes a good teacher? There have been many quests for the one essential trait, and they have all come up empty-handed. Among the factors that do not predict whether a teacher will

succeed: a graduate-school degree, a high score on the SAT, an extroverted personality, politeness, confidence, warmth, enthusiasm and having passed the teacher-certification exam on the first try. When Bill Gates announced recently that his foundation was investing millions in a project to improve teaching quality in the United States, he added a rueful caveat. "Unfortunately, it seems the field doesn't have a clear view of what characterizes good teaching," Gates said. "I'm personally very curious."

When Doug Lemov conducted his own search for those magical ingredients, he noticed something about most successful teachers that he hadn't expected to find: what looked like natural-born genius was often deliberate technique in disguise. "Stand still when you're giving directions," a teacher at a Boston school told him. In other words, don't do two things at once. Lemov tried it, and suddenly, he had to ask students to take out their homework only once.

It was the tiniest decision, but what was teaching if not a series of bite-size moves just like that?

Lemov thought about soccer, another passion. If his teammates wanted him to play better, they didn't just say, "Get better." They told him to "mark tighter" or "close the space." Maybe the reason he and others were struggling so mightily to talk and even to think about teaching was that the right words didn't exist — or at least, they hadn't been collected. And so he set out to assemble the hidden wisdom of the best teachers in America.

LEMOV WAS NOT the first educator to come to the conclusion that teachers need better training. In the spring of 1986, a group of university deans sat in an apartment near the University of Illinois at Chicago, tossing bets into a hat. They had come together to put the final touches on a manifesto that would denounce their own institutions — the more than 1,200 schools of education — for failing to adequately train the country's teachers.

They planned to mail the document to about 100 universities, along with an invitation to join their crusade, a coalition they named the Holmes Group, after a Harvard education-school dean from the 1920s and '30s who pushed to prioritize teacher training. The bets they scribbled on pieces of paper were their guesses as to how many of their colleagues might agree to join them.

"People were saying, 'Well, you're lucky to get 30,' " Frank Murray, the dean of the University of Delaware's school of education, and one of those present, recalled recently.

By the end of the year, nearly every invited dean had signed on. The process of studying their own sins was "painful," Judith Lanier, the chairwoman of the Holmes Group and then the dean of Michigan State University's education school, wrote in an introduction to the final report. But the consensus was inescapable. Three years before, a report from a presidential commission declared the nation to be "at risk" because of underperforming schools, citing dipping test scores and frightening illiteracy. "Our own professional schools are part of the problem," the Holmes Group's report declared.

Though the Holmes report stirred controversy in some quarters — the dean of the College of Education at the University of Cincinnati denounced it as "divisive" and "exclusionary" — almost nobody denied the need for change. Yet reform proved difficult to implement. The most damning testimony comes from the graduates of education schools. No professional feels completely prepared on her first day of work, but while a new lawyer might work under the tutelage of a seasoned partner, a first-year teacher usually takes charge of her classroom from the very first day. One survivor of this trial by fire is Amy Treadwell, a teacher for 10 years who received her master's degree in education from DePaul University, one of the largest private universities in the Chicago area. She took courses in children's literature and on "Race, Culture and Class"; one on the history of education, another on research, several on teaching methods. She even spent one semester as a student teacher at a Chicago elementary school. But when she walked into her first job, teaching first graders on the city's South Side, she discovered a major shortcoming: She had no idea how to teach children to read. "I was certified and stamped with a mark of approval, and I couldn't teach them the one thing they most needed to know how to do," she told me.

The mechanics of teaching were not always overlooked in education schools. Modern-day teacher-educators look back admiringly to Cyrus Peirce, creator of one of the first "normal" schools (as teacher training schools were called in the 1800s), who aimed to deduce "the true methods of teaching." Another favorite model is the Cook County Normal School, run for years by John Dewey's precursor Francis Parker. The school graduated future teachers only if they demonstrated an ability to control a classroom at an adjacent "practice school" attended by real children; faculty members, meanwhile, used the practice school as a laboratory to hone what Parker proudly called a new "science" of education. But Peirce and Parker's ambitions were foiled by a race to prepare teachers en masse. Between 1870 and 1900, as the country's population surged and school became compulsory, the number of public schoolteachers in America shot from 200,000 to 400,000. Normal schools had to turn out graduates quickly; teaching students how to teach was an afterthought to getting them out the door. Thirty years later, the number was almost 850,000.

In the 20th century, as normal schools were brought under the umbrella of the modern university, other imperatives took over. Measured against the glamorous fields of history, economics and psychology, classroom technique began to look downright mundane. Many education professors adopted the tools of social science and took on schools as their subject. Others flew the banner of progressivism or its contemporary cousin constructivism: a theory of learning that emphasizes the importance of students' taking ownership of their own work above all else.

At the same time, well-educated women and racial minorities who once made up a core of teachers began to see that they had other career options, and in increasing numbers, they took them. That left the ever-growing number of teaching jobs to a cohort with weaker academic backgrounds. The labor pool was especially shallow in cities, which, abandoned by the middle class, faced perpetual teacher shortages. Nancy Slavin, the head of teacher recruitment for the Chicago public schools,

described to me a phone call in 2001 that particularly alarmed her. A prospective substitute teacher wanted to know why she hadn't been selected for an assignment. Slavin explained that her conviction for prostitution made her ineligible. "Well," the woman replied, a bit indignant, "I'm in a teacher-training program."

Traditionally, education schools divide their curriculums into three parts: regular academic subjects, to make sure teachers know the basics of what they are assigned to teach; "foundations" courses that give them a sense of the history and philosophy of education; and finally "methods" courses that are supposed to offer ideas for how to teach particular subjects. Many schools add a required stint as a student teacher in a more-experienced teacher's class. Yet schools can't always control for the quality of the experienced teacher, and education-school professors often have little contact with actual schools. A 2006 report found that 12 percent of education-school faculty members never taught in elementary or secondary schools themselves. Even some methods professors have never set foot in a classroom or have not done so recently.

Nearly 80 percent of classroom teachers received their bachelor's degrees in education, according to the U.S. Department of Education. Yet a 2006 report written by Arthur Levine, the former president of Teachers College, the esteemed institution at Columbia University, assessed the state of teacher education this way: "Today, the teacher-education curriculum is a confusing patchwork. Academic instruction and clinical instruction are disconnected. Graduates are insufficiently prepared for the classroom." By emphasizing broad theories of learning rather than the particular work of the teacher, methods classes and the rest of the future teacher's coursework often become what the historian Diane Ravitch called "the contentless curriculum."

When Doug Lemov, who is 42, set out to become a teacher of teachers, he was painfully aware of his own limitations. A large, shy man with a Doogie Howser face, he recalls how he limped through his first year in the classroom, at a private day school in Princeton, N.J. His heartfelt lesson plans — write in your journal while listening to music; analyze Beatles songs like poems — received blank stares. "I still remember thinking: Oh, my God. I still have 45 minutes left to go," he told me recently. Things improved over time, but very slowly. At the Academy of the Pacific Rim, a Boston charter school he helped found, he was the dean of students, a job title that is school code for chief disciplinarian, and later principal. Lemov fit the bill physically — he's 6-foot-3 and 215 pounds — but he struggled to get students to follow his directions on the first try.

After his disappointing visit to Syracuse, he decided to seek out the best teachers he could find — as defined partly by their students' test scores — and learn from them. A self-described data geek, he went about this task methodically, collecting test-score results and demographic information from states around the country. He plotted each school's poverty level on one axis and its performance on state tests on the other. Each chart had a few outliers blinking in the upper-right-hand corner — schools that managed to squeeze high performance out of the poorest students. He broke those schools' scores down by grade level and subject. If a school scored

especially high on, say, sixth-grade English, he would track down the people who taught sixth graders English.

He called a wedding videographer he knew through a friend and asked him if he'd like to tag along on some school visits. Their first trip to North Star Academy, a charter school in Newark, turned into a five-year project to record teachers across the country. At first, Lemov financed the trip out of his consulting budget; later, Uncommon Schools paid for it. The odyssey produced a 357-page treatise known among its hundreds of underground fans as Lemov's Taxonomy. (The official title, attached to a book version being released in April, is "Teach Like a Champion: The 49 Techniques That Put Students on the Path to College.")

I first encountered the taxonomy this winter in Boston at a training workshop, one of the dozens Lemov gives each year to teachers. Central to Lemov's argument is a belief that students can't learn unless the teacher succeeds in capturing their attention and getting them to follow instructions. Educators refer to this art, sometimes derisively, as "classroom management." The romantic objection to emphasizing it is that a class too focused on rules and order will only replicate the power structure; a more common view is that classroom management is essential but somewhat boring and certainly less interesting than creating lesson plans. While some education schools offer courses in classroom management, they often address only abstract ideas, like the importance of writing up systems of rules, rather than the rules themselves. Other education schools do not teach the subject at all. Lemov's view is that getting students to pay attention is not only crucial but also a skill as specialized, intricate and learnable as playing guitar.

At the Boston seminar, Lemov played a video of a class taught by one of his teaching virtuosos, a slim man named Bob Zimmerli. Lemov used it to introduce one of the 49 techniques in his taxonomy, one he calls What to Do. The clip opens at the start of class, which Zimmerli was teaching for the first time, with children — fifth graders, all of them black, mostly boys — looking everywhere but at the board. One is playing with a pair of headphones; another is slowly paging through a giant three-ring binder. Zimmerli stands at the front of the class in a neat tie. "O.K., guys, before I get started today, here's what I need from you," he says. "I need that piece of paper turned over and a pencil out." Almost no one is following his directions, but he is undeterred. "So if there's anything else on your desk right now, please put that inside your desk." He mimics what he wants the students to do with a neat underhand pitch. A few students in the front put papers away. "Just like you're doing, thank you very much," Zimmerli says, pointing to one of them. Another desk emerges neat; Zimmerli targets it. "Thank you, sir." "I appreciate it," he says, pointing to another. By the time he points to one last student — "Nice . . . nice" — the headphones are gone, the binder has clicked shut and everyone is paying attention.

Lemov switched off the video. "Imagine if his first direction had been, 'Please get your things out for class,' " he said. Zimmerli got the students to pay attention not because of some inborn charisma, Lemov explained, but simply by being direct and specific. Children often fail to follow

directions because they really don't know what they are supposed to do. There were other tricks Zimmerli used too. Lemov pointed to technique No. 43: Positive Framing, by which teachers correct misbehavior not by chiding students for what they're doing wrong but by offering what Lemov calls "a vision of a positive outcome." Zimmerli's thank-yous and just-like-you're-doings were a perfect execution of one of Positive Framing's sub-categories, Build Momentum/Narrate the Positive.

"It's this positive wave; you can almost see it going across the classroom from right to left," Lemov said. He restarted the clip and asked us to watch the boy with the binder. At the start his head is down and he is paging slowly through his binder. Ten seconds in, he looks to his left, where another boy has his paper and pencil out and is staring at Zimmerli. For the first time, he looks up at the teacher. He stops paging. "He's like, 'O.K., what's this?' " Lemov narrated. " 'I guess I'm going to go with it.' " After 30 seconds, his binder is closed, and he's stowing it under his desk.

All Lemov's techniques depend on his close reading of the students' point of view, which he is constantly imagining. In Boston, he declared himself on a personal quest to eliminate the saying of "shh" in classrooms, citing what he called "the fundamental ambiguity of 'shh.' Are you asking the kids not to talk, or are you asking kids to talk more quietly?" A teacher's control, he said repeatedly, should be "an exercise in purpose, not in power." So there is Warm/Strict, technique No. 45, in which a correction comes with a smile and an explanation for its cause — "Sweetheart, we don't do that in this classroom because it keeps us from making the most of our learning time."

The J-Factor, No. 46, is a list of ways to inject a classroom with joy, from giving students nicknames to handing out vocabulary words in sealed envelopes to build suspense. In Cold Call, No. 22, stolen from Harvard Business School, which Lemov attended, the students don't raise their hands — the teacher picks the one who will answer the question. Lemov's favorite variety has the teacher ask the question first, and then say the student's name, forcing every single student to do the work of figuring out an answer.

All the techniques are meant to be adaptable by anyone. To illustrate cold-calling in Boston, he showed clips of four very different teachers: Mr. Rector, whose seventh graders stand up next to their chairs as he paces among them, lobbing increasingly difficult geometry problems; Ms. Lofthus, who leans back in a chair, supercasual, and smiles warmly when she surprises one second grader by calling on him twice in a row; Ms. Payne, whose kindergartners jump in their seats, clap and sing along when she introduces "in-di-vid-u-al tuu-urrns, listen for your na-aame"; and Ms. Driggs, a petite blonde with a high voice who calls the process "hot calling" and tells her fifth graders that the hardest part will be that they are not allowed to raise their hands.

But perhaps the greatest master of the techniques in the taxonomy is Lemov himself. When I first met him during the lunch break at the Boston workshop, he spent most of our conversation staring at the floor. He was perched on a windowsill in a small side room, hugging his large body close to

him. “I’m a huge introvert,” he told me, explaining how, at Harvard Business School, he took a Myers-Briggs personality test that labeled him more introverted than all his other classmates. “It’s strange to me that I do what I do and that I like it as much as I do,” he said.

After lunch he returned to the main room to teach, and it was as if he had left the shy Lemov on the windowsill. A different man stood up tall and square-shouldered, with a presence that made all 30 of the teachers crane their necks toward him. When he told a joke, they laughed; when he pointed to the screen, their eyes raced after his finger. One teacher at my table, Zeke Phillips, from Harlem’s Democracy Prep Charter School, raised his eyebrows at a colleague and whispered, “This stuff is good.”

When Lemov began his project, he was working in the relative obscurity of Uncommon Schools. His decision to spend half his time building the taxonomy meant he had less time to carry out the network’s main business, opening schools. But his fellow managing directors made a calculation that the time spent building a vocabulary for teachers would be worth the slower pace. They were beginning to expand beyond their handful of schools, and they needed a hiring plan. Their first schools often relied on experienced teachers like Zimmerli, plucked from other public schools. They could continue to buy the best talent away from other schools, but as more charter-school networks emerged, the competition for the obviously great teachers was growing fierce.

They decided that rather than buy talent, they would try to build it. Today, Lemov’s taxonomy is one part of a complex training regime at Uncommon Schools that starts with new hires and continues throughout their careers. Lemov began expanding the taxonomy beyond Uncommon Schools only recently, offering workshops, like the one I attended in Boston, to a wider audience. His main clients are other charter schools, but they also include Teach for America and an immersive training program in Boston called the Match Teacher Residency that uses medical school as the model for preparing educators. His methods are also used at Teacher U, a new teacher-training program in which Uncommon Schools is a partner. Lemov is interested in offering teachers what he describes as an incentive just as powerful as cash: the chance to get better. “If it’s just a big pie, then it’s just a question of who’s getting the good teachers,” Lemov told me. “The really good question is, can you get people to improve really fast and at scale?”

ANOTHER QUESTION IS THIS: Is good classroom management enough to ensure good instruction? Heather Hill, an associate professor at Harvard University, showed me a video of a teacher called by the pseudonym Wilma. Wilma has charisma; every eye in the classroom is on her as she moves back and forth across the blackboard. But Hill saw something else. “If you look at it from a pedagogical lens, Wilma is actually a good teacher,” Hill told me. “But when you look at the math, things begin to fall apart.”

In the lesson I watched, Wilma is using a word problem to teach her class a concept called “unit rate.” The problem has to do with a boy named Dario who buys seven boxes of pasta for $6. How

expensive is a box of pasta? The correct answer, 86 cents, is found by dividing six by seven, but in the quickness of the moment, Wilma wrongly divides seven by six. This produces the number of boxes Dario can buy for a dollar, not how much money it takes to buy a box. As a result, students spend the rest of the class with the wrong impression that the pasta costs $1.17, as well as the wrong idea of how to think about the problem.

Hill is a member of a group of educators, who, like Lemov, are studying great teachers. But whereas Lemov came out of the practical world of the classroom, this group is based in university research centers. And rather than focus on universal teaching techniques that can be applied across subjects and grade levels, Hill and her colleagues ask what good teachers should know about the specific subjects they teach.

The wellspring of this movement was Michigan State's school of education, which, under the direction of Judith Lanier, one of the original Holmes Group members, took the lead in rethinking teacher education. Lanier overhauled Michigan State's teacher-preparation program and helped open two research institutes dedicated to the study of teaching and teacher education. She recruited innovative scholars from around the country, and almost overnight East Lansing became a hotbed of education research.

One of those researchers was Deborah Loewenberg Ball, an assistant professor who also taught math part time at an East Lansing elementary school and whose classroom was a model for teachers in training. In 1990, Ball filmed her third-grade math class at the Spartan Village Elementary School, and those videos became the foundation for a great deal of teacher-training research.

On one tape from that year, Ball started her day by calling on a boy known to the researchers as Sean.

"I was just thinking about six," Sean began. "I'm just thinking, it can be an odd number, too." Ball did not shake her head no. Sean went on, speaking faster. "Cause there could be two, four, six, and two — three twos, that'd make six!"

"Uh-huh," Ball said.

"And two threes," Sean said, gaining steam. "It could be an odd and an even number. Both!"

He looked up at Ball, who was sitting in a chair among the students, wearing a black-and-red jumper and oversize eyeglasses. She continued not to contradict him, and he went on not making sense. Then Ball looked to the class. "Other people's comments?" she asked calmly.

At this point, the class came to a pause. I was watching the video at the University of Michigan's school of education, where Ball, who has traded in her grandma glasses for black cat's-eye frames,

is now the dean — and one of the country's foremost experts on effective teaching. (She is also on the board of the Spencer Foundation, which administers my fellowship.) Her goal in filming her class was to capture and then study, categorize and describe the work of teaching — the knowledge and skills involved in getting a class of 8-year-olds to understand a year's worth of math. Her somewhat surprising conclusion: Teaching, even teaching third-grade math, is extraordinarily specialized, requiring both intricate skills and complex knowledge about math.

The Sean video is a case in point. Ball had a goal for that day's lesson, and it was not to investigate the special properties of the number six. Yet by entertaining Sean's odd idea, Ball was able to teach the class far more than if she had stuck to her lesson plan. By the end of the day, a girl from Nigeria had led the class in deriving precise definitions of even and odd; everyone — even Sean — had agreed that a number could not be both odd and even; and the class had coined a new, special type of number, one that happens to be the product of an odd number and two. They called them Sean numbers. Other memorable moments from the year include a day when they derived the concept of infinity ("You would die before you counted all the numbers!" one girl said) and another when an 8-year-old girl proved that an odd number plus an odd number will always equal an even number.

Dropping a lesson plan and fruitfully improvising requires a certain kind of knowledge — knowledge that Ball, a college French major, did not always have. In fact, she told me that math was the subject she felt least confident teaching at the beginning of her career. Frustrated, she decided to sign up for math classes at a local community college and then at Michigan State. She worked her way from calculus to number theory. "Pretty much right away," she told me, "I saw that studying math was helping." Suddenly, she could explain why one isn't a prime number and why you can't divide by zero. Most important, she finally understood math's secret language: the kinds of questions it involves and the way ideas become proofs. But still, the effect on her teaching was fairly random. Much of the math she never used at all, while other parts of teaching still challenged her.

Working with Hyman Bass, a mathematician at the University of Michigan, Ball began to theorize that while teaching math obviously required subject knowledge, the knowledge seemed to be something distinct from what she had learned in math class. It's one thing to know that 307 minus 168 equals 139; it is another thing to be able understand why a third grader might think that 261 is the right answer. Mathematicians need to understand a problem only for themselves; math teachers need both to know the math and to know how 30 different minds might understand (or misunderstand) it. Then they need to take each mind from not getting it to mastery. And they need to do this in 45 minutes or less. This was neither pure content knowledge nor what educators call pedagogical knowledge, a set of facts independent of subject matter, like Lemov's techniques. It was a different animal altogether. Ball named it Mathematical Knowledge for Teaching, or M.K.T. She theorized that it included everything from the "common" math understood by most adults to

math that only teachers need to know, like which visual tools to use to represent fractions (sticks? blocks? a picture of a pizza?) or a sense of the everyday errors students tend to make when they start learning about negative numbers. At the heart of M.K.T., she thought, was an ability to step outside of your own head. “Teaching depends on what other people think,” Ball told me, “not what you think.”

The idea that just knowing math was not enough to teach it seemed legitimate, but Ball wanted to test her theory. Working with Hill, the Harvard professor, and another colleague, she developed a multiple-choice test for teachers. The test included questions about common math, like whether zero is odd or even (it’s even), as well as questions evaluating the part of M.K.T. that is special to teachers. Hill then cross-referenced teachers’ results with their students’ test scores. The results were impressive: students whose teacher got an above-average M.K.T. score learned about three more weeks of material over the course of a year than those whose teacher had an average score, a boost equivalent to that of coming from a middle-class family rather than a working-class one. The finding is especially powerful given how few properties of teachers can be shown to directly affect student learning. Looking at data from New York City teachers in 2006 and 2007, a team of economists found many factors that did not predict whether their students learned successfully. One of two that were more promising: the teacher’s score on the M.K.T. test, which they took as part of a survey compiled for the study. (Another, slightly less powerful factor was the selectivity of the college a teacher attended as an undergraduate.)

Ball also administered a similar test to a group of mathematicians, 60 percent of whom bombed on the same few key questions. Wilma, incidentally, scored near the bottom on the M.K.T. test, in the 12th percentile.

Inspired by Ball, other researchers have been busily excavating parallel sets of knowledge for other subject areas. A Stanford professor named Pam Grossman is now trying to articulate a similar body of knowledge for English teachers, discerning what kinds of questions to ask about literature and how to lead a group discussion about a book.

Ball is very clear that she doesn’t think knowledge alone can make a teacher effective, and as part of her efforts to transform the University of Michigan’s teacher-training program, she has begun to classify the particular classroom actions that are also crucial. She and the faculty have settled on 19 practices they want every student to master before graduation. These include some skills related to special knowledge for teaching, but they also include some broader skills, even some that seem to belong in the classroom-management arena, like an ability to “establish norms and routines for classroom discourse.”

Ball and Lemov have never met, and Ball had not heard of Lemov’s taxonomy until I told her about it over a late dinner last December in Ann Arbor. We were joined by Bass, the mathematician, and Francesca Forzani, an alumnus of Teach for America who is managing the university’s teacher-

training overhaul. Ball had just declared that teaching "is decidedly not about being yourself," but the other two were having trouble articulating just how teachers should behave. "That's one thing our program doesn't address right now," Forzani said. "How to get and hold the floor." To answer that question, they began to dissect Ball's methods. What did she do to capture her audience's attention? Bass mimicked how Ball brings order at faculty meetings. "Oh, I notice Deborah is paying attention, and Francesca, and Elizabeth," he said, going through our names. Ball laughed. "That's a joke!" she said, explaining that she is mocking a common classroom technique that she finds manipulative — a way of embarrassing talkers by not addressing them. Her preferred approach, she said, is to say something like, "Elizabeth, I'm a little worried you might not have heard what Hy is saying." Bass shook his head, still thinking about the faculty meetings. "But it works!" he said.

Watching their conversation was like witnessing Lemov's taxonomy in the act of creation. The slightly manipulative narration of this-person-is-paying-attention is a version of something Lemov calls Narrate the Positive; Ball's preferred approach, acting as if the distracted student was actually just *not able to hear* was Lemov's Assume the Best; and getting and holding the floor by adopting a different persona — that was what Lemov calls Strong Voice. The more I talked about the taxonomy with Ball and her colleagues, the more it became clear that she was just as much a master of the 49 techniques as Bob Zimmerli. There were just two small differences. First, whereas Lemov's taxonomy is content-neutral, Ball connects hers to math. The second difference was that, while these practices were so ingrained they seemed imprinted on Ball's soul, when it came to talking about them, to passing them onto her students, she had no words.

THESE DAYS LEMOV is almost single-mindedly focused on the mechanics of teaching, the secret steps behind getting and holding the floor whether you're teaching fractions or the American Revolution. The subject-free focus is a deliberate decision. "I believe in content-based professional development, obviously," he told me. "But I feel like it's insufficient. . . . It doesn't matter what questions you're asking if the kids are running the classroom."

But of course, content comes up for every teacher that uses the taxonomy. I met one such teacher, Katie Bellucci, this winter when I visited Troy Prep in Troy, N.Y., just outside Albany. She had been teaching for only two months, yet her fifth-grade math class was both completely focused on her and completely quiet. Pacing happily in front of a projector screen, she showed none of the false, scripted manner so common among first-year teachers. She moved confidently from introducing the day's material — how to calculate the mean for a set of numbers — to a quick cold-call session to review what they had already learned and finally to helping students as they tackled sample problems on their own. She even sent a disobedient student to the dean's office without a single turned head or giggle interrupting the flow of her lesson. Her cold calls perfectly satisfied Lemov's ideal. First, she asked the question. Then she paused a slightly uncomfortable second. And only then did she name the student destined to answer.

Bellucci, the daughter of two teachers, is a slim brunette with natural presence and a calm confidence. But her control of the classroom, she says, is thanks to the taxonomy, which she began to learn last summer, practicing different techniques in classroom simulations with her fellow teachers. The simulations were specific and practical; Bellucci told me she spent several hours practicing how to tell a student he was off task. “Without it, I’d be completely on my own,” she said. “I’d be in the dark.”

Like a good lesson, the taxonomy includes both basic and advanced material. Lately Bellucci and her mentor teacher, Eli Kramer, a dean of curriculum and instruction at Troy who also splits fifth-grade math responsibilities with Bellucci, have advanced to a technique called No Opt Out. The concept is deceptively simple: A teacher should never allow her students to avoid answering a question, however tough. “If I’m asking my students a question, and I call on somebody, and they get it wrong, I need to work on how to address that,” Bellucci explained in February. “It’s easy to be like, ‘No,’ and move on to the next person. But the hard part is to be like: ‘O.K., well, that’s your thought. Does anybody disagree? . . . I have to work on going from the student who gets it wrong to students who get it right, then back to the student who gets it wrong and ask a follow-up question to make sure they understand why they got it wrong and understood why the right answer is right.”

Part of the challenge with the higher-level techniques is that they involve not just universal teaching practices but actual math. Bellucci doesn’t just have to remember to return to the student who made the mistake; she has to figure out some way to correct that mistake in the student’s brain. For these kinds of challenges, Bellucci leans on Kramer’s seven years of experience teaching math, plus her own applied math degree from nearby Union College. She also improvises.

In other words, she could use help explaining content — the kind of thinking Ball is trying to teach education students with Math Knowledge for Teaching. Lemov and other Uncommon Schools administrators are unfamiliar with M.K.T., but some are recognizing that content can’t be completely divorced from mechanics. This fall, Uncommon Schools administrators began building new taxonomy-like tools around specific content areas. Among the subjects under analysis are elementary- and middle-school reading, upper-grade math and all levels of science.

Lemov and Ball focus on different problems, yet in another way they are compatriots in the same vanguard, arguing that great teachers are not born but made. (The Obama administration has also signaled its hopes by doubling the budget for teacher training in the 2011 budget to $235 million.) A more typical education expert is Jonah Rockoff, an economist at Columbia University, who favors policies like rewarding teachers whose students perform well and removing those who don’t but looks skeptically upon teacher training. He has an understandable reason: While study after study shows that teachers who once boosted student test scores are very likely to do so in the future, no research he can think of has shown a teacher-training program to boost student achievement. So why invest in training when, as he told me recently, “you could be throwing your

money away"?

Indeed, while Ball has proved that teachers with M.K.T. help students learn more, she has not yet been able to find the best way to teach it. And while Lemov has faith in his taxonomy because he chose his champions based on their students' test scores, this is far from scientific proof. The best evidence Lemov has now is anecdotal — the testimony of teachers like Bellucci and the impressive test scores of their students. (Among the taxonomy's users are a New Orleans charter school that last year had the third-highest ninth-grade English scores in the city behind two selective public schools; the highest-rated middle school on New York City's school report card; and top schools in Boston, Milwaukee, Denver and Newark.)

THOMAS KANE, a Harvard economist who studies education, used to belong to Rockoff's skeptical camp. But he is one of several researchers who told me recently that he now has a more open mind. "I still think tenure review is important," he said. "It's just, I don't think we should throw in our towel on the other things." There is simply too much potential in improving the vast number of teachers who neither drag their students down nor pull them ahead.

By figuring out what makes the great teachers great, and passing that on to the mass of teachers in the middle, he said, "we could ensure that the average classroom tomorrow was seeing the types of gains that the top quarter of our classrooms see today." He has made a guess about the effect that change would have. "We could close the gap between the United States and Japan on these international tests within two years."

Kane is serious about finding the answers. He took a leave from Harvard in 2008 to work on a $335 million Gates Foundation project that will identify and support effective teaching practices. One study involves filming some 3,000 classrooms across the country and measuring them against a variety of practices, including an M.K.T.-based rubric created by Hill and her colleagues.

Lemov, for his part, finds hope in what he has already accomplished. The day that I watched Bellucci's math class, Lemov sat next to me, beaming. He was still smiling an hour later, when we walked out of the school together to his car. "You could change the world with a first-year teacher like that," he said.

Elizabeth Green is a Spencer fellow in education reporting at the Columbia University Graduate School of Journalism and the editor of GothamSchools.org. This is her first article for the magazine.

This article has been revised to reflect the following correction:

Correction: March 21, 2010

An article on March 7 about new methods for training teachers misstated the size of DePaul University, where one teacher interviewed on the subject studied. It is one of the largest private

universities in the Chicago area, with about 25,000 students, not a small one.