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Mathematics boils down to pattern recognition. We identify patterns in the world around us and use them to navigate its challenges. To do all this, however, we need figures - or at least the information that our figures represent. What are numbers? When we'll explore more later, it's a deceptively deep question, but you already know the simple answer. A number is a word and a symbol that represents a count. Let's say you go outside your home and you see two angry dogs. Even if you didn't know the word two or know what the corresponding figure looks like, your brain would have a good grasp of how a two-dog encounter compares to a three-, one- or zero-dog situation. We are required to innate understanding to our brain (especially the inferior parietal lobe), which naturally extracts numbers from the surrounding environment in much the same way that it identifies colors [source: Dehaene]. We call this number feeling, and our brains come fully equipped with it from birth. Studies show that while infants have no grasp of human numbering systems, they can still identify changes in quantity. Neuroimaging research has even discovered that infants have the ability to engage in logarithmic counting, or counting based on integrated increases in physical quantity. While a child won't see the difference between five teddy bears and six teddy bears in a lineup, he or she will notice a difference between five and 10 [source: Miller]. Number ing plays an important role in how animals navigate in their environments - environments where objects are numerous and often moving. However, an animal's sense of numbers becomes more imprecise with increasing numbers. Humans, for instance, are systematically slower to calculate 4 + 5 than 2 + 3 [source: Dehaene]. At some point in our ancient past, prehistoric people began to develop a way to increase their number of feeling. They started counting on their fingers and toes. That's why so many numerical systems rely on groups of five, 10 or 20. Base-10 or decimal systems are derived from the use of both hands, while base-20 or vigesimal systems are based on the use of fingers and toes. So ancient people learned to externalize their number of feeling and, in this way, they undoubtedly created humanity's most important scientific achievement: mathematics. There is a calculus to knitting. An untamed batch of wool gets twisted and fed into a spinning wheel, a wooden thing about as high-tech as an abacus, which binds the fibers into a single string of yarn. This yarn, in turn, is woven into geometric patterns consisting of equations: A certain number of rows combined with certain stitches provides something functional and beautiful. In the right hands, knitting produces an exact but almost magical alchemy–chaos in order. You can see why it would appeal to Brenda Dietrich.Dietrich, 47, runs department at IBM's famous famous J. Watson Research Center–the top math director at arguably the largest and most important mathematics department in corporate America. She loves the beauty and complexity of math. Still, she often spends conference calls and spinning twine meetings on the wheel next to her ThinkPad. And she knits incessantly–a scarf, coat, shawl and on the gait at the same time. That exquisite blue and purple cashmere shawl in her office? This was last year's strategy for research programs, she says. I sat in the back row knitting for three days. Dietrich, who has coauthored 13 patents and has twice been named one of IBM's top inventors, likes to do stuff-tangible things, not just kits. As a mathematician, she has a rare ability to travel between two very different worlds, said Paul Horn, director of IBM research. She can listen to a customer describe the messy details of a company, then translate those specifications into mathematical problems for her team to solve. And she thinks mathematicians should live in the real world, the world of customers. When she took over the mathematics department in 2001, she encouraged researchers to venture outside Watson, whom she calls the beautiful stone building on the hill, and work with IBM consultants in the field. These days, her team is in fact heading out from years of behind the scenes, mostly theoretical research to address an impressive array of real-world issues at IBM and beyond. How to assemble a project team from consultants scattered around the world. How to fight large forest fires more effectively. How to identify the best sales leads going on. OnTarget, the sales-prediction software that grew out of math research, generated $100 million in new revenue as a pilot program in Canada. Last year, it delivered about $500 million in worldwide use, a sum that makes Dietrich giggle as if she can't quite believe it. Dietrich's 160 researchers are in fact increasingly among the most valuable problem solvers at IBM. Historically, the stars here have been physicists who made the technology that went into chips and systems, and then there were computer scientists and engineers, Horn says. Now we see the emergence of mathematicians. They're embedded everywhere. This is partly due to IBM's transition from hardware to software and services. And part of it, certainly, is a function of Dietrich's marketing and political savvy: A nerd, but far from the personality-challenged stereotype, she understands how to win attention and resources in an organization of 330,000 people. More than that, her department's growing impact reflects a major real change. A generation ago, companies urged mathematicians, at best, to optimise production lines and perhaps support pricing decisions. What else can they possibly contribute to the bottom line? Today, companies measure almost every of what they do, and computers are fast enough to crunch the numbers in time for managers to act on the analysis. In the hands of talented mathematicians, data creates an invaluable advantage. Elaborate algorithms reveal a company's inefficiencies and opportunities—unseen bottlenecks in the supply chain or customers' hidden buying patterns. Whole business–think Google – is built almost entirely around math. And others, like IBM, integrate mathematics into operation and decision-making in a way never before seen. This is how the industrial age must have been for mechanical engineers. It's a great time, Dietrich says, to be a computational mathematician. A number theory class at the University of North Carolina at Chapel Hill changed Dietrich's mind about becoming a doctor. Math was a revelation, like hearing music for the first time. There is structure and symmetry and the most wonderful theory, she said. It made me believe in any underlying order in the world. Dietrich, whose husband is an IBM software architect, joined the company in 1984 after earning her Ph.D. in business research and industrial engineering at Cornell, and she applied that wonderful theory to designing more efficient chip-making lines. It was exciting to see how useful mathematics can be. In the mid-1990s, she got bored between projects–a dangerous situation, she laughs—and pursued a new set of problems, spending six months in the field alongside IBM consultants and clients. They couldn't tell you the addicted and independent variables, she said. But she could, and that ability to translate the practicality into the theoretical (and back) was powerful. In a way, her experience was the basis for how her research department now works. Unless you're a mathematician, the deep mathematics that Dietrich and her team perform sound completely foreign–combinatorial auctions, integer programming, conditional logic, and so on. Their whiteboard scribbles on Watson look incomprehensible, like Farsi or Greek (then again, many of the symbols are Greek). But these mysterious equations represent the real world and how it works. When mathematicians model a problem, they create a numerical snapshot of a dynamic system and its variables. Take the forest fire project Dietrich and the researchers are working on. Putting out rapidly spreading flames over tens of thousands of acres is an expensive and complicated business. In 2000, a particularly devastating year, the federal government spent more than $1 billion and still lost more than 8 million acres. Its fire planners want to reduce costs and damage through better coordination between the five agencies concerned. Armed with seven years of data, IBM mathematicians create a huge model that shows how resources–every firefighter, truck, etc.–have been used in the past, how much each effort cost, and how many hectares burned. The algorithms describe the likely costs and results of a number of strategies to combat a particular fire. How many bulldozers and buckets do you have in Yellowstone Park? Dietrich asks. And if you need to move them somewhere else, how much will it cost and how long will it take? She talks fast, describing the unruly variables that mathematics makes sense of. It's a nice project. Complicated, huh? Uh, yes. For years, mathematicians were so focused on basic research that they wouldn't go near projects like this–and they weren't asked to, either. It was like working at a university without even the burden of teaching, said longtime researcher Baruch Schieber. When you decided what to work with, the first consideration was not, how will this affect the company? If the researchers wanted, they could close their office door and focus on the most esoteric research, uninterrupted–and isolated. At first, Horn says, putting math specialists in front of customers made everyone nervous, not least of all customers. The scientists are undeniably brilliant, he says, laughing, but one wonders how some of them come home at night. Watson, located an hour north of New York, has a relaxed, collegiate feel; sneakers and jeans, along with the occasional bushy beard and ponytail, are the norm. Assertive, professorial types fit right in. Dietrich may seem ingenious and charmingly odd, but when she holds forth on the intricacies of mathematics, she can be daunting. She does not suffer fools and enjoys a good debate. But Dietrich has learned to soften his strategy to avoid undermining consultants' relationships with clients. She helped create a class for researchers explaining the consulting process and culture. A mathematician perfectionism must give way to deadlines. The smartest-person-in-the-room vibe is considered to be of-putting, rather than an invitation to match intelligence. Instead of forcing an argument about logic, as we're trained to do—it's a bit adversarial— you have to keep quiet and listen, she says. And you have to stay out of the technical muck. Some longtime mathematicians initially worried that research would suffer under Dietrich. Instead, they live a double life. In fact, says researcher Robin Lougee-Heimer, projects like the one she's working on now, a nationwide distribution puzzle for a brand customer, uncover fertile research topics. I get into big trouble, she says, with nasty details and complexity. It used to be that Schieber, a senior manager in optimization, would hear about a project within IBM and sometimes reach out to consultants. They rarely answered his calls. Now he says: I'm the selective. When we first started asking resources consultants use on projects, they said each project was different. It just drove me crazy. The word is out: The math team can help. Dietrich fields a few dozen requests a month, half of which she declines because the problem has already been resolved or not is challenging enough. We want to push the boundaries of what is solvable, she said. Otherwise, what's the point? In a sense, Dietrich is doing what she enjoyed as a young math whiz-solving word problem. Here's a doozy: After IBM's sales team signs a consulting agreement, the company often has to assemble the project team on deadline—say, 50 Java developers in Chicago by the following Monday. It can choose from 190,000 consultants around the world with different skills, personalities, and availability. It must do this for thousands of projects a year for customers of all sizes in all possible industries. Meanwhile, the mix of projects and available consultants is constantly changing. When we first started asking what resources consultants use in projects, they said that each project was different, dietrich says. It just drove me crazy. By poring over two years of project data, mathematicians identified which skills are most commonly applied in certain types of assignments. You may not know exactly what the customer wants, but now you have an approximate idea who you need for a $5 million project compared to a $50 million project, said Dan Connors, optimization manager for the Workforce Management program. This staffing analysis tool helped managers anticipate demand and schedule accordingly, increasing consultants' productivity 7% and reducing travel costs and the use of external contractors. The savings exceeded $500 million. So do the math: Add sales from OnTarget forecasting tools, and that's a $1 billion contribution from Dietrich's math whizzes. Brainiacs tackles another problem whose solution can be just as valuable: how to choose the best teams. Project managers tend to select the most talented developers and engineers available, or those they already know. It may work well for the project at hand, but in the long run, it doesn't necessarily benefit IBM as a whole; better to spread the talent around. Researchers are also creating a social-networking analysis that would assess traces of emails, instant messages and phone calls to identify which teams act as flat organizations and which are hierarchical—which work well together and who don't. But the problem that really grips Dietrich involves predicting the workforce in the future. By analyzing population trends, employee demographics and skills, and demand for certain technologies, her researchers hope to identify labor shortages in various functions and occupations before they occur. That work, almost unimaginably complex and far-reaching, is near complete. Each answer generates new questions, and that's fine. That's good. Even mathematicians don't have all the answers. Dietrich does not get bored, and she will turn out some lovely knitting. Eventually she will have numbers that will help us think differently about the world and where it is on the road—and IBM and its customers will hire or train employees accordingly. It may, of course, turn out that what they need is more mathematicians. Mathematician.

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