Learning to Love Our Robot Co-Workers

The most important frontier for robots is not the work they take from humans but the work they do with humans — which requires learning on both sides.

By KIM TINGLEY • FEB. 23, 2017

The Future of Work

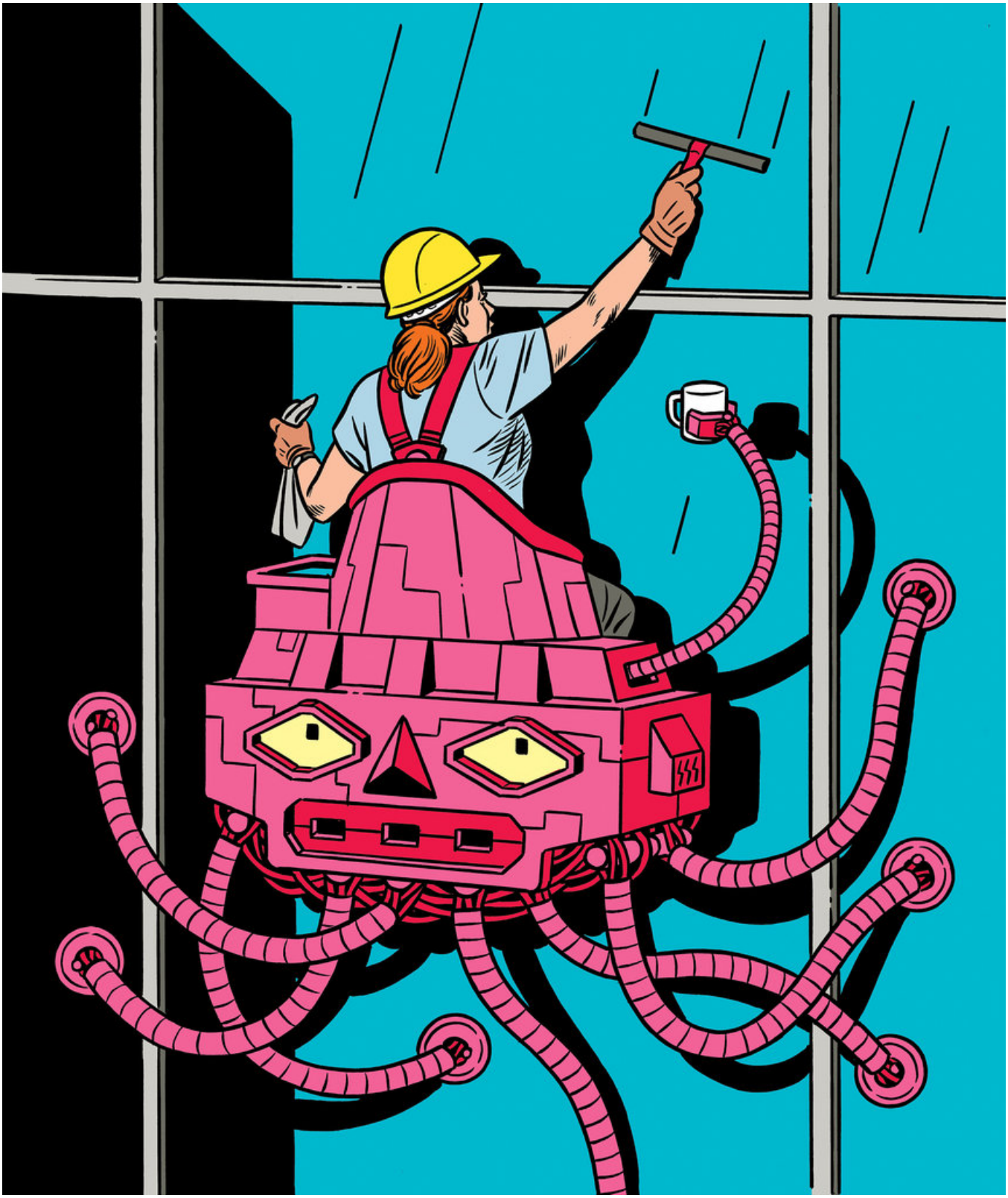

Illustration by Kristian Hammerstad

The robots were Joe McGillivray's idea. The first one arrived at Dynamic Group in Ramsey, Minn., by pickup truck in two cardboard boxes. With a mixture of excitement and trepidation, McGillivray watched as a vendor unpacked two silver tubes, assorted blue-and-gray joints and a touch screen and put them all together. When he was finished 10 minutes later, McGillivray beheld an arm that, had its segments not all been able to

swivel 360 degrees, might have belonged to a very large N.B.A. player or a fairly small giant. Its “shoulder” was mounted to a waist-high pedestal on wheels. If it were to hail someone across the room, its “elbow” would reach eye level. Below its “wrist,” which was triple-jointed for extra dexterity, there were sockets for various attachments. McGillivray, not sure yet if he wanted to keep the contraption, stuck a piece of clear tape to the wrist and drew a happy face on it, which made the arm look a bit as if it were putting on a puppet show. He hoped that this would help it look nonthreatening.

McGillivray is the 38-year-old chief executive of Dynamic, a maker of molds for the mass production of small plastic and metal parts, from 3M Scotch-tape dispensers to bullets. The company was founded 40 years ago by his father, Peter, and Peter’s friend Dave Kalina, both tool and die makers, in Kalina’s basement. Machining like theirs is labor-intensive. Even as the business expanded to more than 100 employees in two warehouses in Ramsey — a manufacturing town founded by French traders and settled in the 1850s on the banks of the Mississippi River — many of its customers switched to competitors overseas, induced by improvements in the technologies of developing nations coupled with falling trade barriers. But McGillivray and Kalina found a lucrative niche making molds for the most intricate medical products. Orthodontic braces, for example, use brackets that have unique shapes based on the angles of the teeth to which they will be affixed; the bracket molds, which are injected with powdered steel, must be cut to a degree of precision 40 times thinner than a hair. Thanks largely to the skill of Dynamic’s machinists, the company did more than survive; it prospered. Then came the Great Recession. For the first time, McGillivray and Kalina, once able to offer bonuses, struggled to make payroll. To keep going, they needed to produce more molds or cut costs, or both.

Last month, on a damp, gray day, Joe McGillivray took me on a tour of one of Dynamic’s facilities, a former steel factory adjacent to a railroad track. The walls were painted cream with green trim, and the thick hum of motors made the cavernous space feel almost cozy. He led me to an injection press the size of a bakery oven. Inside, a nozzle moved up and

down, shooting molten plastic into a mold, where it cooled around the end of a catheter tube. The resulting piece, when the tube was placed in a patient, would be used as a connector by a surgeon threading tools like scopes or stents into his or her body. A young man in a hairnet, gloves and goggles sat at a table facing the press. The robot was beside him.

Before the robot arrived, McGillivray told me, four people worked the press. One inserted the catheter tubes into a frame that held them still; one set the frame on a mold, ran it through the press and took it out; one removed the finished tubes from the frame and trimmed away excess plastic; and one inspected the final products. The process was unforgiving: If an operator hit the stop button an instant too late, the plastic burned, ruining the part. Inevitably, even the nimblest foursomes produced lots of scrap.

Now, as we watched, the operator inserted two tubes into a frame and put it on a rack. The robot, which had a sensor and a magnetic pad attached to its end, tapped the frame with its pad to pick it up, pivoted and gently placed the frame on a mold inside the press. Then it cocked its wrist and nudged a button with one of the pad's corners. A wheel inside the press spun like a lazy susan, 180 degrees, positioning the mold beneath the nozzle and bringing around a second mold with a frame of cooled catheters. Next the robot lifted this frame and moved it to a trimmer that ejected the catheters. Finally, it stacked the empty frame beside the operator. The cycle took 35 seconds. All the while, the operator examined finished catheters and inserted tubes into frames at a steady but unhurried pace.

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It wasn't the robot's speed that was revolutionary, McGillivray said; other automated machines could do the same things faster. The innovation was its "collaborative" ability: This robot is safe to work with. If it bumps into someone, it stops. (McGillivray, a father of three young daughters whose standards of personal responsibility are marked even by Minnesotan

standards, tested this feature on himself first: “Let’s just say it hit a fleshy part of my body, and I didn’t like it. But it didn’t leave a bruise.”) This meant that he didn’t have to build an expensive, semi-permanent safety cage around it. And because the robot is easy to move and reprogram, it can quickly be reassigned to whatever unique processes are required to fill the one-off orders Dynamic typically receives.

The robot’s price tag was $35,000, and within two months, it paid for itself by quadrupling the efficiency of the press and eliminating scrap. There was one caveat, though: “Productivity did decrease when we first put the robots in,” McGillivray said, “because they’re so dang fun to watch.” He has since purchased two more of them from Universal Robots, a Danish company, and hired a technician to maintain them. No one was laid off, and the company’s finances are sounder than they have been in nearly 20 years. “I guess I’m kind of an evangelist,” he told me.

“It’s just a machine?” my husband said, when he saw a picture of the arm I had flown a thousand miles to see. “I thought you said it was a *robot*.” In fact, it was both — a robot is technically just a machine run by a computer — but I knew what he meant because I had gone there with the same expectation. I presumed that the robot would look and act like a human and, consequently, that it would make me and the people who worked with it a little uncomfortable.

The more I talked with engineers and civilians alike, the more I came to believe that this feeling was hardly unusual and that it went beyond the perfectly rational fear that a robot might take your job. “My deep worry is that every time you see a robot doing what a human does, there’s this visceral response — it’s human nature,” Julie Shah, a professor of aeronautics and astronautics at M.I.T. and the leader of its Interactive Robotics Group, told me. This response is so intense, and so crucial to people’s acceptance or rejection of robots, that Masahiro Mori, a Japanese robotics professor, famously graphed it in 1970. He found that our affinity for robots increases as they come to look more and more human — until the point when the likeness is similar enough to momentarily fool the eye.

Once the illusion is discovered, the viewer is unsettled and affinity plunges, a dip Mori dubbed “the uncanny valley.” The danger is that our uneasiness will prevent us from preparing for a future in which robots interact with humans in increasingly sophisticated ways, and one that — thanks to rapid advances in computing and mechanical engineering — is coming, and coming soon.

Much of the current political upheaval in the United States and other Western democracies can be traced to how threatened we feel when faced with this future. Central to Donald Trump’s presidential campaign, and presumably to his victories in manufacturing states like Michigan, Ohio and Pennsylvania, was his promise to bring back the 10 percent of factory jobs that have disappeared in the wake of the Great Recession. But the fact is, American manufacturers are producing more products now than they were before the crash, with fewer workers, which suggests that those missing jobs have been automated. And while collaborative robots are showing up on factory floors first — where automation has always debuted, taking on repetitive, heavy and hazardous work — they are likely to find their way into other workplaces soon. (The “collaborative” label, widely used to imply coexistence, is a bit misleading; robots that can learn, problem-solve and simulate human emotion are still confined mostly to laboratories.) Already, surgical robots make it possible via remote control to perform low-risk operations in outpatient settings; robot home-health aids may soon help people with limited mobility get out of bed, cook meals and perform other routine tasks; and driverless vehicles are poised to take over the transportation and trucking industries. It doesn’t take much imagination to see how similar algorithms, or operating instructions, could enable robots to do many of the tasks required of waiters, maids and hospital workers. A few years ago, Amazon purchased Kiva Systems, which coordinates warehouse robots whose job is to move heavy boxes to stations where human stockers, whose fine motor skills have yet to be affordably mechanized, transfer the boxes to shelves.

“We’re moving into an era where people and infrastructure are in a more fluid relationship,” says David Mindell, a professor of aerospace

engineering and the history of technology at M.I.T. The question is who will reap the economic rewards of that change. “We tend to think that automation, generally speaking, replaces humans, but really in the big picture that isn’t true,” James Bessen, an economist at Boston University, told me. Instead, it makes goods cheaper, increasing demand and creating more jobs. Only when a product or service becomes so cheap and ubiquitous that lowering its price can’t get people to buy any more of it does automation result in significant unemployment — unless the displaced workers are absorbed by a growing market for a different product or service, or the labor force shrinks.

Collaborative robots, designed to fill flexible roles and be smaller and easier to integrate among employees and existing machines, may have a subtler effect, raising the need for more nuanced measures of their socioeconomic impact. In one recent study, Carl Frey and Michael Osborne of the University of Oxford broke down 702 occupations in the United States in detail and analyzed the probability that they would be computerized. Nearly half of those jobs were found to have a “high risk” of being automated within the next few decades. Telemarketers, accountants, retail salespeople, technical writers and real estate agents would be first; chemical engineers, clergy, athletic trainers and dentists last. Conversely, a new McKinsey Global Institute report argues that we should stop considering “entire occupations” and instead focus on “individual activities.” A server must deliver and clear plates (tasks a robot might take over), but he or she also observes diners and anticipates their needs (tasks at which people are still far superior). From this perspective, fewer than 5 percent of careers can be completely automated using existing technology — but “about half of all the activities people are paid to do in the world’s work force could potentially be.”

In the West, Frankenstein’s monster embodies the threat of cutting-edge technology. We adopted the word “robot” from a popular 1921 play by the Czech writer Karel Capek about a factory that turns out robots, from *robota*, a Czech word for forced labor, who rise up and exterminate humanity. But the citizens of Singapore, Korea and Japan, the world’s

leading users of industrial robots, and China, the most rapidly growing market for them, generally don't share the same anxieties. In the Japanese canon, new technology often arrives as weaponry that Japanese scientists turn against an aggressor. (The nuclear parable of "Tetsuwan Atom," a 1960s TV show about a heroic Japanese robot with an "atomic" heart, was lost in translation when it arrived in America as "Astro Boy.") Viewing them through a different cultural lens, might we expect collaborative robots to augment a person's skills, increasing his or her productivity — and thus value — without ruining any lives? Could we look forward to programming these machines to make our jobs better without fear of them usurping us? Or is it naïve to imagine that, if we cooperate with the robots, there won't come a day when they can do everything we can do, only better, and their owners become our masters?

Ever since the invention of the transistor in 1947 started the transformation of computing — just a couple of years after the United States destroyed Hiroshima and Nagasaki with atomic bombs — philosophers have anticipated a day when intelligent machines would do all our work for us. Some pictured a dystopia like the one Jeremy Rifkin described in his 1995 book, "The End of Work": "Like a deadly epidemic inexorably working its way through the marketplace, the strange, seemingly inexplicable new economic disease spreads, destroying lives and destabilizing whole communities in its wake."

Others envisioned a society in which profits were distributed evenly in the form of a basic income, leaving people to spend their time as they pleased. The Rev. Dr. Martin Luther King Jr., in his final sermon, exhorted his congregation toward this idyll of equality and freedom. "Yes, we do live in a period where changes are taking place," he said, naming "automation and cybernation" among them. "And there is still the voice crying through the vista of time saying, 'Behold, I make all things new; former things are passed away.' "

Still others believed both scenarios were equally plausible and the outcome would depend upon how judiciously we regulated new technologies,

nuclear fission being a powerful example, so that they reduced, rather than increased, human suffering. Chief among them was Norbert Wiener, a mathematics professor at M.I.T., who coined the term “cybernetics” to describe the study of the relationship between living beings and robots. “We can be humble and live a good life with the aid of machines,” he wrote, “or we can be arrogant and die.”

Anyone wishing to cross the threshold of the General Motors automotive assembly plant in Lake Orion, Mich., just outside Detroit, must sit in the lobby and watch a safety video. From a TV mounted in a corner above a realistic-looking ficus tree, a pleasant female voice details all the possible things inside that could hurt you: loud noises, flying objects, sharp metal, molten metal, falls from high places and collisions with mobile equipment. It’s both a testament to one of the main applications for collaborative industrial robots — to take over dangerous work from people and to be less dangerous to work with — and an illustration of the difficulties inherent in getting them to do and be so.

The physical world presents robots with challenges that most toddlers navigate with ease: selecting a Lego from a bin, falling over and standing back up. The foundation of computing, transistors, are made of hard, rigid silicon, a substance at odds with the soft, flexible contours of our bodies — and the world we’ve designed to conform to them. “I’m just teaching robots how to pick up stuff, and I think it brings to light how much we take for granted about these things,” says Siddhartha Srinivasa, a computer-science and engineering professor at the University of Washington, who designs robots to help people with spinal-cord injuries navigate everyday environments. “When you make coffee or you pick up something, you’re performing these beautiful intricate maneuvers.”

The collaborative robots entering manufacturing today are not doing anything nearly as elaborate. In fact, much of the technology they use is decades old. What’s new is the conviction that they are safe, a position largely cemented in 2011, when the International Organization for Standardization added new language to its industrial-safety guidelines to

address their implementation. Soon afterward, General Motors and its partner Fanuc (Fuji Automated Numerical Control), a Japanese robotics company whose American headquarters is a few miles from Lake Orion, initiated their first collaborative-robot project.

At 4.3 million square feet, Lake Orion is one of G.M.'s smaller plants and the only one in the United States efficient enough to produce compact cars, for which profit margins are much thinner than those of larger vehicles. Overhead, candy-colored Chevy Sonics and electric Bolt EVs travel in cages hanging from tracks near the ceiling as if en route up a ski slope. Their serene pace belies both the bodily risks posed by large moving objects that are insensitive to obstacles and the disaster lurking within all such circuits: a short anywhere along the line that decommissions the whole. On an assembly line turning out a $50,000 vehicle every minute, for instance, six hours of "unscheduled downtime" for repairs represents a potential loss of $18 million. A major benefit of Fanuc's robots, 30,000 of which are already working in G.M. plants noncollaboratively, is that 8,000 of them are linked to the internet via cloud computing, so engineers can monitor their health and recommend preventive maintenance.

The streamlined nature of operations at Lake Orion makes it an ideal testing ground for new production tools, including G.M.'s first collaborative robot, a supersize version of Dynamic's but with an exterior like that of a foam pool noodle. The engineers at G.M. and Fanuc agonized over what color it should be. Orange screamed "danger"; yellow suggested "caution." They settled on a neon-lime hue they dubbed "safety green." It stood next to a conveyor belt, lifting 35-pound tires and stacking them on a cart. The employees who once performed this duty had relinquished it gladly; even with the assistance of a lift, twisting to move the tires from belt to cart was the stuff of ergonomic nightmares.

'This one is completely safe. It's kind of like a pet dog. I forget it's there.'

On the day I visited, the area supervisor was Diana Reed. A Detroit-area native, she had worked at the plant for more than a decade. Every two hours, she leaned under the robot to check tire pressures. When I asked

what it was like working with it, she gestured to an earlier section of the conveyor, where behind a fence, a hydraulic press was picking up wheels and slamming them into tires with a hiss. “That one I’m scared to death of; it could crush me,” she said. “This one is completely safe. It’s kind of like a pet dog. I forget it’s there.”

Whereas the exoticism of a collaborative robot in Dynamic’s workplace caused employees to stop and stare, G.M.’s robots fit right in to an already heavily automated environment. At a glance, it was actually Reed, a petite woman in a ponytail, who looked most out of place amid stacks of tires that were almost as tall as she was. I had been reading Karl Marx, who, in the wake of the Industrial Revolution, accused machines of “supplying capital with weapons against the revolts of the working class.” But observing Reed in action with her robot, I could also see how collaborative robots might have a democratizing effect, giving people of various ages, sexes, dexterities and sizes an equal shot at excelling at all sorts of physically demanding careers. True democratization would require access to collaborative robots across industries, and it occurred to me that perhaps the profoundest difference between the coming wave of robot-driven automation and industrial revolutions of the past is that both Joe McGillivray and G.M. can afford to participate.

And to the extent that collaborative robots are blank slates — multifunctional and reprogrammable as opposed to major investments whose functions are determined at purchase — they offer employees an opportunity to experiment. Far more than past automations did, they give their operators, as much as their owners, the power to influence how they will be used to maximize the time the operators spend on the facets of their jobs that they find most fulfilling.

Later that afternoon, up the road, Fanuc’s executives delighted in Reed’s pet metaphor. She was exactly the sort of tech-savvy employee they were hoping to recruit to build, maintain and program their growing fleet of robots. We meandered through their machine shop, where classes were underway. Over the past decade, Fanuc has trained 47,000 students to use

its equipment; nonetheless, the consulting firm Deloitte recently projected that two million manufacturing-related jobs will lack qualified applicants by 2025.

In the Fanuc showroom, “delta” robots — upside-down pyramids of springy arms — sorted fake batteries, EpiPens and prescription pills by shape and color, pecking at them with the speed of sewing-machine needles. Nearby, the world’s largest robot arm with joints was swinging a Corvette through the air. One potential customer had debated attaching a nozzle that would allow the robot to 3-D-print a concrete house.

“My confidence in having the robots do whatever we want is through the roof,” Richard Maxwell, the company’s engineering director, said. The only limiting factor he could see was cost.

Fanuc’s chief executive, Mike Cicco, was eager to dispel the notion that manufacturing jobs are sweaty and boring. “It’s a really cool alternative for someone who doesn’t want to be a lawyer,” he said. “It’s fun, it’s rewarding —”

Claude Dinsmoor, Fanuc’s general manager, finished the thought: “It’s not your grandfather’s manufacturing.”

‘I think people still have value. If the answer to everything is that the only people who have value are the programmers, we might as well give up.’

As it happens, my grandfather was a manufacturer — a machinist who later in life started a business with his son, my father, making voice coils for audio speakers in his garage in Bokeelia, Fla. He died at the height of a manufacturing boom born of the ’90s dot-com bubble, leaving my father to handle the layoffs that came when the bubble burst a few years later and their largest customer began buying its coils directly from China. Within two years, the company had cut 100 of its 170 assembly-line workers. It now specializes in custom coils and employs about 45 people, a third of whom have been there for more than 20 years.

My father took considerable satisfaction in my assignment to, as he saw it,

report his life story. For a couple of weeks, I called to regale him with visions of a future in which robots become so much like us that they teach us about ourselves. At the M.I.T. Media Lab, researchers have programmed a "growth mind-set" into robots that have enough personality to engage preschoolers in puzzle games. An initial study showed that playing with these robots, which respond to adversity with statements like "I will do better next time," increased the likelihood of children's believing that they can improve with practice: The robot was a teacher but also an experimental control for testing theories of mind. Across the street, Julie Shah is designing robots that can shadow people in highly instinctual jobs, like head nurses, and detect patterns in how they make decisions. This would enable the nurses to use them to help train rookies.

Why wouldn't such a robot just do the job itself? The number of data points required for one to "learn" to fold a towel autonomously, let alone run an E.R., is staggering. But it would be relatively easy for a person wearing virtual-reality goggles — anywhere in the world — to inhabit a robot and fold towels until enough points were collected, Louis Hyman, an economic historian at Cornell University, told me. Would-be immigrants could physically occupy jobs here from home.

Ultimately, the only impediment to the total dissemination of robots may be our appetite for human interaction. "We want a salesperson we can relate to," James Bessen told me. "We like to have a financial adviser whom we personally trust." Similarly, David Mindell said, we feel more comfortable when people help us interface with automation at places like airports.

"I think people still have value," Hyman added. "If the answer to everything is that the only people who have value are the programmers, we might as well give up."

In January, at Dynamic's annual company meeting, Joe McGillivray gave a speech. He described his vision of a system that transforms raw materials into finished products by itself. "One-touch manufacturing," he called it. He believed it would create more jobs that would pay better and be more

fulfilling. “There’s a knowledge they have,” he said of his machine operators, “from doing this by hand for so many years, invisible algorithms they know, and none of those machines would work without that.” Still, he acknowledged that even with training, not all of his employees would succeed at translating their experience into binary language. “I hope that number is very small for us, but it’s troubling,” he said. “My big question is: Are we going to be happy? I get a lot of fulfillment from what I do. Will I have that if I work 20 hours a week?”

There’s a good chance that the greatest struggles over how to incorporate collaborative robots into the work force — and possibly the most ingenious solutions — will happen at small-to-medium-size businesses like Dynamic, where the relationships among owners, workers and robots are most intimate. In the Dynamic conference room, dubbed the Think Tank, an aquarium is populated with guppies, and the words “Creating what you imagine” are painted on the wall. It seemed a little corny, but as McGillivary described how the company had switched from a “suggestion box” to an “If you see something you can change to make your job better, just do it” mandate, a policy that by his calculations had resulted in 1,800 improvements over four years, I was reminded that engineers can solve problems only if they know about them. An inventor who has never been a server or talked at length with one is blind to the invisible preparations and attentions that make a meal in a restaurant go smoothly, and thus apt to believe that a robot need only handle plates and credit cards to do a server’s job.

My father, who often puts in 70-hour weeks while contemplating retirement, felt an instant bond with McGillivray as I described him and the way he talked about his own small business. He understood the satisfaction, my father perceived, even pleasure that comes from tracing a path with your fingers so many times that your thoughts drift and for a moment you become inseparable from the thing you are making. On weekends, my father rises early and goes to work so that he can set up and run his machines alone, spinning copper wire into coils that will lie on an eyeball or fit in medical implants. When he returns home, his Levi’s hold

the same faint aroma of industrial glue I remember from childhood, when the front door opened in the evening and I threw my arms around his legs.

But as my father and my grandfather and pretty much any engineer would tell you, sentimentality is the enemy of progress. My grandfather hated the machine grease that lodged under his fingernails — that he spent hours scrubbing away. He would have loved the new robots.

“That future is coming,” McGillivray told me, when I asked him how his speech was received. “We can be among the first to do it and get so far ahead that it will be hard for anyone to catch us. We can do it along with everyone else and remain competitive. Or we can not get on the train and get left behind. And I didn’t see anyone disagreeing with that.”