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WHY THE EXPERT-NOVICE BOND MATTERS IN THE AGE OF INTELLIGENT TECHNOLOGY

Matt Beane

Consider ancient Athens, 507 BC.

Twelve-year-old Menelaos begins his second year as apprentice to Stephanos, the master sculptor. Today, like yesterday, he walks to the carpenter's workshop for lumber. Then to the brass smith for pins and braces. Brings it all back and keeps it organized as the senior boys finish the scaffolding for a new piece. All day, he hauls blocks of marble around the workshop, directed by the senior boys, who take their cues from Stephanos. As the sun goes down, he's cleaning up after everyone.

Throughout, he's been watching. Noticing the marble scraps and bent tools. Listening as they told stories and talked technique. Asking a question or two while he did his work. Next year, if he works hard, he'll be splitting the marble. Keeping tools organized and sharp. And learning about the next tasks up the apprenticeship chain—roughing out blocks, negotiating for supplies, talking to customers. And six years later, he will be carving his first solo work in his own studio on the outskirts of the city, new apprentices looking up to him.

This is all likely true, by the way: we have one of his masterworks, a marble statue of Orestes and Electra, signed "Menelaos, the pupil of Stephanos."

Fast-forward to Rochester, Minnesota, 2020. It's 6:30 in the morning when twenty-six-year-old Kristen wheels her prostate patient into the operating room. She's a resident, a surgeon in training—it's her job to learn. Today she's hoping to do some nerve-sparing—a precise kind of dissection that can preserve erectile function. This is one of surgery's most delicate techniques, and it's critical to the success of the procedure.

Kristen and the team put the patient under anesthesia, and she leads the initial eight-inch incision in the lower abdomen. Once she's got the skin, fascia, and muscle clamped back, she tells the nurse to call the attending surgeon. He arrives, gowns up, and for the rest of the two-hour surgery their four hands are mostly inside the patient's body, with Kristen leading the way under the attending surgeon's watchful guidance.

When the prostate is out—and, yes, the surgeon let Kristen do a little nerve-sparing—he rips off his scrubs. He starts to do paperwork. Kristen closes the patient by 8:15, with a junior resident looking over her shoulder. She even lets him do the final line of sutures. There's about half an hour of the procedure to go, but Kristen feels great. The patient is going to be fine, and no doubt she's a better surgeon than she was at 6:30.

Think about your most valuable skill. The thing you can reliably do under pressure that delivers results—and looks like magic to those nearby. How did you learn it?

Decades of research suggest that you achieved mastery the same way Menelaos and Kristen did: by working with someone who knew more than you did. More specifically, by watching an expert for a bit, getting involved in easy, safe parts of the work, progressing to harder, riskier tasks with their guidance, and then finally starting to guide others.

In surgery, this is called "see one, do one, teach one." But no matter what we call it, whether we even know it's going on, it's the same process—in pipefitting, midwifery, or carpentry, in an elementary school classroom or a high-energy-physics lab. And we have clear archaeological evidence of this process going back at least to the invention of language and the bow: about 160,000 years ago.

Welcome to the expert-novice bond—a relationship that predates most of what we consider to be civilization. Experts can't do what they do without help. Novices want to help, and to learn. So they build a collaborative bond that's also the engine for building skill.

But wait, what about books? School? Workshops? Even Khan Academy or YouTube? Hasn't our increasingly connected, up-to-date, inexpensive, global academy taken center stage away from this old-school bond?

Nope. The research is clear on this, too—formal learning, at best, just gets you table stakes. It lets you start playing the game. But having conceptual knowledge *about* the work or doing practice exercises is very different from being able to do the work under pressure.

To get there, most of us still rely primarily on collaboration with an expert. That relationship shapes our work so that we slowly, incrementally build layers of know-how that allow us to get results when it counts. If we step back from our own personal experience—if we look at human history as a long chain of relationships and interactions—this is how skill gets developed and passed between generations.

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When something works this well, for this long, and for this many of us, we take it for granted. Question this and you might as well wonder if the sky is blue. But its success actually hinges on a set of essential criteria. If any of these are missing, skill dies, and the chain of excellence is at risk of being broken. And right now, as we transform more and more workplaces with intelligent technologies, these criteria are under threat.

THE THREAT

In millions of workplaces, we're blocking the ability to master new skills because we are separating junior workers from senior workers, novices from experts, by inserting technology between them. In a grail-like quest to optimize productivity, we are disrupting the components of the skill code, taking for granted the necessary bundling of challenge, complexity, and connection that could help us build the skill we need to work with intelligent machines.

People often ask me: "Are robots going to take our jobs?" The immediate answer is yes: the best available research shows that for every robot that a firm buys, between three and six jobs are lost. But there's a far more important question afoot than job losses. It's how many and what kinds of jobs we're *changing*.

For over forty years, the research has shown one and only one pattern: when we put automation or even new technology to work, we don't eliminate many jobs, relative to the economy. Think tens of thousands. But many, many jobs change a little bit to accommodate the new way of working implied by the new technology. Think tens or even hundreds of millions. Which means that all those folks have to figure out the new way and get to a place where they can do it reliably.

Smell skill development anywhere? Your nose is working. Learning is our critical challenge by a country mile because job change affects billions of us, and the pace of change is picking up.

Let's go back to Kristen in the OR to see how this is already playing out. Six months after her open surgical rotation, she wheels another prostate patient into the operating room where, this time, a hulking robot is waiting. The attending surgeon attaches the four-armed, thousand-pound robot to the patient. Then they both rip off their scrubs and head to control consoles fifteen feet away to do the whole operation "remotely."

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Kirsten just watches as her attending manipulates the robot's arms, retracting and dissecting tissue. Unlike the technologies that dot the history of surgery, using the robot makes it iPhone-easy for him to do the whole procedure himself. He knows Kristen needs practice; he wants to give her control. But he also knows she would be slower and make more mistakes, and she'd be going it alone. Slower means more time under anesthesia, which causes strokes. And mistakes mean blood loss, or worse. His patient comes first.

So, Kristen has no hope of getting anywhere near those nerves during this rotation. In fact, she'll be lucky if she operates more than fifteen minutes during this four-hour procedure, and that will be on super-easy, safe stuff like cutting through fat. And when she does, he yells critiques at her across the room for all to hear, or, if she really slips up, he'll tap a touch screen and take control, banishing her to the sidelines, feeling like a kid in a dunce cap. No chance she's a better robotic surgeon after this procedure.

This adds up: Kristen and most of her fellow residents finish their training without much robotic confidence or surgical mastery. In her first independent job as a surgeon, Kristen sweats on the console. She stops, starts, pauses, and moves slowly. Burns and cuts a lot of extra tissue. There's a lot of tense silence and concerned looks between surgical staff. The patient loses about ten times more blood than they would have in the hands of Kristen's mentor, and what should have taken three hours takes seven.

When I talked to Kristen's chief of surgery about what I witnessed in the robotic operating room, I asked him what he thought the implications of this new technique were for the profession. He had grave concerns. He pointed out that, while there were a few superstar robotic surgeons in the country, the vast majority of those operating with robots just didn't have the skill they should. He said, "I mean these guys can't do it. They haven't had any experience doing it. They watched it happen. Watching a movie doesn't make you an actor."

That got my attention.

Yet demand for robotic surgery is increasing rapidly; many hospitals have such a system and will pressure new surgeons like Kristen to use it. So, she will operate with it anyway.

In 2019, *U.S. News & World Report* and *Wired* magazines independently investigated this and found robotic surgical training remained a "wild west," getting "terrible" results. In 2022, *IEEE Spectrum*—the number one global popular magazine for engineers—found the same. Many of us will go under the robotic knife with a surgeon who didn't get enough training, doesn't handle enough cases to keep their chops sharp, and doesn't feel all that confident when they sit down at the console.

Find this disturbing? I do, too. And it's only the beginning.

In each of these settings there's a different intelligent technology at work, yet the same bonds are being severed.

As with several other professions, surgery has been an early adopter of intelligent technologies, sitting at the very tip of the nose cone of the rocket we're building for ourselves, blasting into a brave new world.

Now imagine this spreading across dozens of occupations and organizations. Then hundreds. Then around the globe. That's what's happening. Right now. I've taken a close look at the available data from dozens of those early-adopter domains and it shows we have already begun to break the learning encoded in apprenticeship-style interaction across a broad swath of professions.

Top corporate law firms are cutting costs aggressively, but they're spending more on one thing: technologies like AI "to support lawyers' workflow." Practically, this means automating document review. The firm doesn't involve or bill for that junior lawyer's time anymore, so senior experts do more, faster; clients pay less while the law firm can bill more with fewer staff so their profit goes up. But as a result, juniors become separated from seniors, losing visibility and exposure to their day-to-day work, and can't learn by helping. A recent Law.com review article sounded the alarm: "There is a whole generation of lawyers missing out on training and professional development."

Cops now get a predictive AI-assist for more productive beat assignments, and that means more time on crime, right? Not for recruits, who have to fill out the paperwork that feeds these systems instead of spending time in the community with their mentors.

In high finance, senior bankers' deepening investments in tools like FactSet and CapIQ now give them ready access to AI-enabled market analysis and firm valuations. So, 2021 saw a record $170 billion profits. Except this automation changed workflows so that junior bankers spent most of their time on rote reports, away from senior bankers, who see "a weakening of (juniors) really understanding the trends and what's going on with the business."

From the cutting edge it's clear: the expert-novice connection is fraying where human and machine learning collide.

I have top-quality data on this problem from all sectors of the global economy. A significant chunk of this comes from more than ten years of my own research, but I've also gotten access to comparable data from other superb field researchers.

Beyond the examples just above, here's a partial list of affected occupations that I'm adding to all the time: higher education, online labor platforms, chip design, journalism, data science, criminal justice, neonatal intensive care, public education, music composition, robotics, open innovation, aerospace engineering, ridesharing, long-haul trucking, bomb disposal, drone piloting, food service, secondary fulfillment, radiology, construction, wealth management, retail, automotive engineering, call center operations. In each of these settings there's a different intelligent technology at work, yet the same bonds are being severed. Almost every time.

This is a multitrillion-dollar problem.

Let's break this down: Recent estimates suggest that the skills gap—the skills that an industry needs, but can't find—costs us a trillion dollars in the global manufacturing industry alone. Multiply that by every industry: for three years running, attracting and developing talent has topped the charts in the Conference Board's survey of the problems that keep CEOs up at night. And workers, too: in one Deloitte survey of workers in 2020, 45 percent of respondents felt that their skills would be inadequate in three years. In another by LinkedIn, a whopping 94 percent of respondents said they would stay at a company longer if it invested in their career development.

If we're not careful, our individual and collective adaptability could fade, just when we need it most.

On top of all that, we're approaching this backward. Almost all of the half-trillion dollars we spent in 2020 on skills development went to formal training: in the classroom, online self-paced tutorials, or—more recently—video clips on a worker's cell phone. Only a tiny fraction was devoted to the ubiquitous, informal bond at the foundation of our most valuable skills. And that pittance is being spent without an up-to-date understanding as to how that bond functions.

Why? The deal with AI is too good to pass up: these systems get better results by extending experts' impact. Try telling a senior journalist, mechanic, or executive to let now-optional trainees back in to struggle, add mistakes, and slow things down.

Kristen's story—and dozens like hers, across industries, technologies, time, and roles—reveal what's at stake. In search of better results, more efficiency, and higher profits, we are designing these intelligent technologies, directing them, and making choices about what research to invest in. And we're paying a hidden, multitrillion-dollar price for it.

Technologies, techniques, and skills come and go, and even the way the traditional expert-novice relationship plays out has shifted over time to accommodate the increasingly complex skills required to get results. Menelaos couldn't use something called a "smartphone" to call, email, or send photos to Stephanos from the markets in Rome, after all. But we've always had time to adapt.

Critically, we've done that through expert-novice collaboration itself—to build the know-how required to stitch together new technologies, techniques, and working relationships. Now this kind of learning is a real struggle, and it's getting harder.

This systematic assault is a death knell for expert-novice collaboration as we've known it for centuries, and with it goes the valuable skill that flows from following the skill code of challenge, complexity, and connection. The next generation of skilled workers is getting gutted, and organizations are hollowing themselves out as a result. If we're not careful, our individual and collective adaptability could fade, just when we need it most.

We have a huge opportunity—and a dire need—to recode our work and our technologies so they enhance challenge, complexity, and connection and the valuable skills that flow from them. **We need to seize it before it's too late.**

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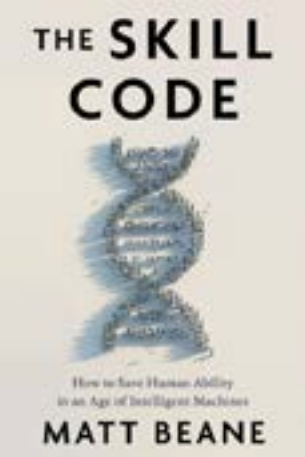

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ABOUT THE AUTHOR

Matt Beane does field research on work involving robots and AI to uncover systematic positive exceptions that we use across the broader world of work. He has published in top management journals such as *Administrative Science Quarterly* and *Harvard Business Review*, and spoken on the Ted stage. He also took a two-year hiatus from his doctoral studies to help found and fund Humatics, an MIT-connected, full-stack IoT startup. Beane is an Assistant Professor in the Technology Management Department at the University of California, Santa Barbara and a Digital Fellow with Stanford's Digital Economy Lab and MIT's Institute for the Digital Economy. He received his PhD from the MIT Sloan School of Management.

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