

Range: Why Generalists Triumph in a Specialized World, David Epstein (2019)

Tiger Woods, who was trained for golf from the age of 7 months, has come to symbolize the idea that the quantity of deliberate practice determines success—and its corollary, that the practice must start as early as possible. Roger Federer dabbled in skiing, wrestling, swimming, basketball, handball, soccer and skateboarding—before he tried tennis. Both dominated their sport, yet with contrasting journeys.

Great Britain's massive success at the recent Summer Olympics was bolstered by programs set up specifically to recruit adults to try new sports and create a pipeline for late developers. Eventual elites typically devote *less* time early on to deliberate practice in the activity in which they will eventually become experts. Instead, they undergo what researchers call a "sampling period." They play a variety of sports, usually in an unstructured or lightly structured environment. They gain a range of physical proficiencies from which then can draw to learn about their own abilities and proclivities, and only later do they focus and ramp up technical practice in one area.

When I began to write about these studies I was met with both thoughtful criticism and denial. A study of German soccer found that those who participated in more sports and non-organized soccer improved more by age 13. The professed necessity of hyper-specialization forms the core of a vast, successful, and sometimes well-meaning marketing machine in sports and beyond. In reality, the Roger path to sports stardom is far more prevalent than the Tiger path. Tom Brady was drafted into professional baseball before football. For athletes, coaches, and military veterans, early career specialists jumped out to an earnings lead after college, but later specialists made up for the head start by finding work that better fit their skills and personalities.

The Tillman Foundation, in the spirit of the late NFL player who left a professional football career to become an Army Ranger, provides scholarships to veterans, active-duty military, and military spouses who are undergoing career changes or going back to school. Scholarship recipients brimmed with enthusiasm, but rippled with an undercurrent of fear. Their advantage of experience had somehow morphed in their heads into a liability. They have been told, implicitly or explicitly, that changing directions was dangerous.

I dove into work showing that highly credentialed experts can become so narrow-minded that they actually get worse with experience, even while becoming more confident—a dangerous combination. I've found that learning itself is best done slowly to accumulate lasting knowledge, even when that means performing poorly on tests of immediate progress. That is, the most effective learning looks inefficient; it looks like falling behind. The drive to specialize infects not just individuals, but entire systems, as each specialized group sees a smaller and smaller part of a large puzzle. Overspecialization can lead to collective tragedy even when every individual separately takes the most reasonable course of action (i.e. the banking industry in 2008). Highly specialized health care professionals have developed their own versions of the "if all you have is a hammer, everything looks like a nail" problem. Increasing specialization has created a "system of parallel trenches" in the quest of inno-

vation. Some scientists are taking it upon themselves to attempt to *despecialize* the training of future researchers.

I worried that I was a job-commitment-phobic drifter who must be doing this whole career thing wrong. But learning about the advantages of breadth and delayed specialization has changed the way I see myself and the world. The challenge we all face is how to maintain the benefits of breadth, diverse experience, interdisciplinary thinking, and delayed concentration in a world that increasingly incentivizes, even demands, hyperspecialization.

Golf and chess clearly benefit from early childhood discipline. But how many of the things humans want to learn and do are really like chess and golf? Experts in an array of fields are remarkably similar to chess masters in that they instinctively recognize familiar patterns. Firefighting commanders make about 80% of their decision instinctively and in seconds. Naval commanders 95% of the time recognize a common pattern and choose a common course of action. But when probing the judgment of highly trained experts, we often found that experience had not helped at all. Even worse, it frequently bred confidence but not skill.

Experience did not create skill in a wide range of real-world scenarios, from college administrators assessing student potential to psychiatrists predicting patient performance to human resources professionals deciding who will succeed in job training. In those domains which involved human behavior and where patterns did not clearly repeat, repetition did not cause learning. **Whether or not experience led to expertise, depended entirely on the domain in question.** Narrow experience made for better chess and poker players and firefighters, but not for better predictors of financial or political trends, or of how employees or patients would perform. Pattern recognition worked in "kind" learning environments, where patterns repeat over and over, and feedback is accurate and rapid.

In "wicked" domains, however, the rules of the game are often unclear or incomplete, there may or may not be repetitive patterns and they may not be obvious, and feedback is often delayed, inaccurate, or both. **Machines perform well in kind environments, but poorly in wicked ones, and humans vice versa.** Chess is 99% tactics—short combinations of moves that players use to get an immediate advantage on the board. Bigger-picture planning in chess is called strategy. Grandmasters seem to have photographic memories, but mostly through repetitive study of game patterns, have learned to "chunk," to group pieces into a smaller number of meaningful chunks based on familiar patterns. Chunking explains instances of apparently miraculous, domain-specific memory, from musicians playing long pieces by heart to quarterbacks recognizing patterns of players in a split second and making a decision to throw. The reason that elite athletes seem to have superhuman reflexes is that they recognize patterns of ball or body movements that tell them what's coming before it happens.

Our greatest strength is the opposite of narrow specialization. It is the ability to integrate broadly. In open ended real-world problems, we're still crushing the machines. In the rule-bound but messier world of driving, AI has made tremendous

progress. But in a truly open-world devoid of rigid rules and reams of perfect historical data, it has been disastrous. AI systems are like savants. They need stable structures and narrow worlds. Tiger's story gives the false impression that human skill is always developed in an extremely kind learning environment, but it doesn't even work in most sports. When experienced accountants were asked in a study to use a new tax law for deductions that replaced a previous one, they did worse than novices—a phenomenon called "cognitive entrenchment."

Scientists induced into the highest national academies are much more likely to have avocations outside of their vocation. And those who have won the Nobel Prize are more likely still. It appears as though they are scattering and dissipating their energies, while in reality they are channeling and strengthening them. Those who did not make a creative contribution to their field lacked aesthetic interest outside their narrow arts.

Claude Shannon launched the Information Age thanks to a philosophy course he took at University of Michigan, where he was exposed to the work of self-taught 19th-century logician George Boole. It was the fundamental insight on which computers rely. Early in their careers, those who later made successful transitions had broader training and kept multiple "career streams" open even as they pursued a primary specialty. Successful adapters were excellent at taking knowledge from one pursuit and applying it creatively to another, and at avoiding cognitive entrenchment. Their skill was in *avoiding* the same old patterns.

The Flynn effect--**the increase in correct IQ test answers with each new generation in the 20th century—has been documented in 30 countries.** The gains are startling: 3 points every 10 years. **An average adult today compared to adults a century ago would be in the top 98th percentile.** Kids today massively bested their grandparents in imperceptible concepts (law, pledge, citizen). Today's children are far better at solving problems on the spot without a previously learned method for doing so. The greater the dose of modernity, the more likely an individual grasped abstract concepts of shapes and groupings.

Premodern people miss the forest for the trees; modern people miss the trees for the forest. We now see the world through "scientific spectacles." We make sense of reality through classification schemes, using layers of abstract concepts to understand how pieces of information relate to one another. Computer programmers pile layers of abstraction. Conceptual schemes are flexible, able to arrange information and ideas for a wide variety of uses, and to transfer knowledge between domains.

Research on thousands of adults in 6 industrializing nations found that exposure to modern work with self-directed problem solving and nonrepetitive challenges was correlated with being "cognitively flexible." Even recently, within some very traditional or orthodox religious communities that have modernized but that still block women from engaging in modern work, the Flynn effect has proceeded more slowly for women than for men in the same community. In every cognitive direction, the minds of premodern citizens were severely constrained by the concrete world before them.

Modern life requires range, making connections across far-flung domains and ideas. The ability to move freely, to shift

from one category to another, is one of the chief characteristics of abstract thinking. Higher education has responded to the broadening of the mind by pushing specialization, rather than focusing early training on conceptual, transferable knowledge. There is no correlation between the test of broad conceptual thinking and GPA. The traits that earn good grades do not include critical ability of any broad significance. Everyone needs habits of mind that allow them to dance across disciplines. Students must be taught to think before being taught what to think about.

I rushed into extremely specialized scientific research without having learned scientific reasoning. (And then I was rewarded for it, with a master's degree). Fermi—who created the first nuclear reactor—constantly made back-of-the-envelope estimates to help him approach problems. Several studies have found that a little training in broad thinking strategies can go a long way, and can be applied across domains.

Like chess masters and firefighters, premodern villagers relied on things being the same tomorrow as they were yesterday and were poorly equipped for everything else. They were perfectly capable of learning from experience, but failed at learning *without* experience. The more constrained and repetitive a challenge, the more likely it will be automated.

17th-century Venice music underwent a complete revolution. Some new instruments were brand new, like the piano; others were enhanced, like the violin; the concerto was born. The girls and women who delighted delicate ears had not lived delicate lives. Many of their mothers worked in Venice's vibrant sex industry and contracted syphilis before they had babies and dropped them off at the House of Mercy, where the girls grew up and learned music. What magical training mechanism was deployed to transform the orphan foundlings into the world's original international rock stars? The most surprising feature was how many instruments they learned. They frequently changed instruments and learned to play every instrument their institution owned. They participated in an extraordinary period for instrument invention and reinvention.

Parents increasingly want their kids to get a head start in music. But the sheer amount of lessons or practice time is not a good indicator of exceptionality. Too many lessons at a young age may not be helpful. Those children identified as exceptional turn out to be those who distributed their effort more evenly across 3 instruments. The most common path to excellence was a sampling period, often lightly structured with some lessons, followed only later by a narrowing of focus, increased structure, and an explosion of practice volume. Jazz and folk and modern popular musicians and singers do not follow a simple, narrow trajectory of technical training, and they start much later.

Duke Ellington said, "As far as anyone teaching me, there was too many rules and regulations...As long as I could sit down and figure it out for myself, then that was all right." He had learned to learn, and his multi-instrument and poly-genre skill became renowned. Django was a Romani who could neither read music nor study it, but was the single most important guitarist in the history of jazz. Examination of the development of improvisational form showed the childhoods of professionals as "one of osmosis," not formal instruction. Improv masters learn like babies: dive in and imitate and improvise first, learn

the formal rules later. The jazz musician is a creative artist, the classical musician is a re-creative artist. Children learn to read after their ability to talk has been well established.

Breadth of training predicts breadth of transfer. The more contexts in which something is learned, the more the learner creates abstract models, and the less they rely on any particular example. Learners become better at applying their knowledge to new situations, which is the essence of creativity. Creativity may be difficult to nurture, but it is easy to thwart. The parents with creative children made their opinions known after their kids did something they didn't like; they just did not proscribe it beforehand. Their households were low on print restraint.

“Desirable difficulties” are obstacles that make learning more challenging, slower, and more frustrating in the short term, but better in the long term. Excessive hint-giving does the opposite; it bolsters immediate performance, but undermines progression in the long term.

One of those desirable difficulties is known as the “generation effect.” Struggling to generate an answer on your own, even a wrong one, enhances subsequent learning. It requires the learner to intentionally sacrifice current performance for future benefit. Being forced to generate answers improves subsequent learning even if the generated answer is wrong. “Hypercorrection effect” means that the more confident a learner is of their wrong answer, the better the information sticks when they subsequently learn the right answer. Tolerating big mistakes can create the best learning opportunities.

The more hints that were available during training, the better monkeys performed during early practice, and the worse they performed on test day. Training without hints is slow and error-ridden. It's, essentially, what we normally think of as testing, except for the purpose of learning rather than evaluation. Used for learning, testing, including self-testing, is a very desirable difficulty. Struggling to retrieve information primes the brain for subsequent learning, even when the retrieval itself is unsuccessful. Like life, retrieval is all about the journey.

Space between practice sessions creates the hardness that enhances learning. Short-term rehearsal gave purely short-term benefits. Struggling to hold on to information and then recall it helped transfer the information from short-term to long-term memory. Repetition was less important than struggle. Learning is most efficient in the long run when it is inefficient in the short run. It is difficult to accept that the best learning road is slow. It is so deeply counterintuitive that it fools the learners themselves, both about their own progress and their teachers' skill. Students gave the best marks to professors who provided them with the least long-term benefit. They were actually punishing the teachers who provided them the most long-term benefit. The most basic message is that teachers and students must avoid interpreting current performance as learning—fast but fleeting progress.

Americans have increasingly said in national surveys that current students are getting a worse education than they themselves did, and they have been wrong. Unquestionably, students today have mastery of basic skills that is superior to students of the past. School has not gotten worse. The goals of education have just become loftier. Increasingly jobs that pay

well require employees to solve unexpected problems, often while working in groups. These shifts in labor force demands have in turn put new and increasingly stringent demands on schools.

Knowledge increasingly needs to not merely be durable, but also flexible—both sticky and capable of broad application. For knowledge to be flexible, it should be learned under varied conditions, an approach called “interleaving.” Interleaving is a desirable difficulty that often holds for both physical and mental skills. It improves the ability to match the right strategy to a problem—the hallmark of expert problem solving. The most successful problem solvers spend mental energy figuring out what type of problem they are facing before matching a strategy to it, rather than jumping in with memorized procedures.

Desirable difficulties make knowledge stick and become durable. They slow down learning and make performance suffer in the short term. Programs like Head Start did give a head start, but researches found a pervasive “fadeout” effect, where a temporary academic advantage quickly diminished and often completely vanished. The fadeout was not a disappearance of skill so much as the rest of the world catching up. There is no evidence that rushing it matters. **Teaching kids to read a little early is not a lasting advantage.** Teaching deeply means learning slowly.

A kind world is based on repeating patterns. Our experience-based instincts are set up well for Tiger domains. The trouble with using no more than a single analogy is that it does not help battle the natural impulse to employ the “inside view.” The outside view probes for deep structural similarities to the current problem in different analogies.

90% of major infrastructure projects worldwide go over budget (by an average of 28%) in part because managers focus on the details of their project and become overly optimistic. Evaluating an array of options *before* letting intuition reign is a trick for the wicked world. The more distant the analogy, the better it is for idea generation. The intuition is to use too few analogies, and to rely on those most superficially similar.

The Integrated Science Program finds few academic departments as fans. Most of them want students to take more specialized classes in a single department. But successful problem solvers are more able to determine the deep structure of a problem before they proceed to match a strategy to it.

Kepler did something that turns out to be characteristic of today's world-class research labs. Rather than assuming the current theory is correct and that an observation must be off, the unexpected became an opportunity to venture somewhere new—and analogies served as the wilderness guide. The labs in which scientist had more diverse professional backgrounds were the ones where more varied analogies were offered, and where breakthroughs were more reliably produced. All forces align to incentivize a head start and early, narrow specialization, even if that is a poor long-term strategy.

The late starts of many artists were integral to their eventual success. Learning stuff was less important than learning about oneself. **Exploration is not just a whimsical luxury of education; it is a central benefit.** If we treated careers more like dating, nobody would settle down so quickly. Switchers are

winners. There are 2 components of grit: work ethic; and “consistency of interests”—direction, knowing exactly what one wants.

Some people might start memorizing root words for the National Spelling Bee and then realize it is not how they want to spend their learning time. That could be a problem of grit, or it could be a decision made in response to match quality information that could not have been gleaned without giving it a try. **“Winners” quit fast and often** when they detect that plan is not the best fit, and do not feel bad about it. **Knowing when to quit is a big strategic advantage.**

Investment in officer training has recently played out exactly backward for the Army: OCS trainees stay the longest, followed by ROTC trainees who did not receive any college scholarship, followed by ROTC trainees who received 2-year scholarships, followed by ROTC trainees with 3-year scholarships, followed finally by West Point graduates and full-scholarship ROTC trainees. From the military’s perspective, this is a major backfire. It was an institution that taught its cadets to get out of the Army. The problem was not an incentive or financial one; it was a matching one.

In the industrial era, or the “company man” era, firms were highly specialized, with employees generally tackling the same suite of challenges repeatedly. By the 1980s the knowledge economy created overwhelming demand for employees with talents for conceptualization and knowledge creation and control over career trajectory shifted from the employer to the employee. While the world changed, the Army stuck with the industrial-era ladder. When a junior officer changed direction and left the Army, it signaled that a strong drive for personal development had changed his goals entirely. “I’ve yet to meet a classmate who left the Army and regretted it.” All were grateful for the experience, even though it didn’t become a lifelong career. Where dangling money for junior offices failed miserably, facilitating match quality succeeded. Growing self-knowledge kept changing my goals and interests until I landed in a career the very lifeblood of which is investigating broad interests.

One of the compelling aspects of sports goals is how straightforward and easily measurable they are. Olympic athletes need to understand that the rules for life are different from sports. Finding a goal with high match quality in the first place is the greatest challenge, and persistence for the sake of persistence can get in the way. Humans are bedeviled by the “sunk cost fallacy.” (Having invested time or money in something, we are loath to leave it, because that would mean we had wasted our time or money, even though it is already gone). Conmen begin by asking their marks for several small favors or investments before progressing to large asks.

Frances Hesselbein, eventual mentor to world leaders, did whatever seemed like it would teach her something and allow her to be of service at each moment, and somehow that added up to training. Some “undefinable process of digestion: occurred as diverse experience accumulated.” I was unaware that I was being prepared. I just learned by doing what was needed at the time.” She saw both the power of inclusion and exclusion. She learned resourcefulness as a jack-of-all-trades; she relied on shared leadership. A mind kept wide open will

take something from every new experience. She had no long-term plan, only a plan to do what was interesting or needed at the moment.

I feel sorry for people who know exactly what they’re going to do from the time they’re sophomores in high school. It’s actually riskier to make a commitment before you know how it fits you. Our work preference and life preferences do not stay the same, because we do not stay the same. It’s the “end of history illusion.” From teenagers to senior citizens, we recognize that our desires and motivations changed a lot in the past (see your old hair style), but believe they will not change much in the future. **We are works in progress claiming to be finished.** Qualities that feel immutable changed immensely. Core values—pleasure, security, success, and honesty—transformed. Preference for vacation, music, hobbies, and even friends were transfigured. The precise person you are now is fleeting, just like all the other people you’ve been. The only certainty is change, both on average as a generation ages, and within each individual.

Some personality traits change over time in fairly predictable ways. Adults tend to become more agreeable, conscientious, emotionally stable, and less neurotic with age, but less open to experience. The most momentous personality changes occur between 18 and one’s late 20s, so specializing early is a task of predicting match quality for a person who does not yet exist. If you get someone into a context that suits them, they’ll more likely work hard and it will look like grit from the outside. **We are ill-equipped to make ironclad long-term goals when our past consists of little time, few experiences, and a narrow range of contexts. We learn who we are only by living, and not before.** We maximize match quality throughout life by sampling activities, social groups, contexts, jobs, careers, and then reflecting and adjusting our personal narratives. And repeat. We learn who we are in practice, not in theory.

Begin with trying something temporary, or finding a new role mode, then reflecting on the experience and moving to the next short-term plan. Be a scientist of yourself, asking smaller questions that can actually be tested—“Which among my various possible selves should I start to explore now? How can I do that?” Test-and-learn, not plan-and-implement.

Most of the work I’ve done in the last 10 years didn’t exist when I was in high school. In such a world it’s not a good idea to have fixed plans. Avoid premature optimization—**instead of working back from a goal, work forward from promising situations.** This is what most successful people actually do anyway. Look at the options available now, and choose those that will give you the most promising range of options afterward. **I know who I am when I see what I do.** You don’t know what’s good and what’s bad until after things happen.

Knowledge is a double-edge sword. It allows you to do some things, but it also makes you blind to other things that you could do. Academic departments no longer merely fracture into subspecialties, they elevate narrowness as an ideal. **Polymaths are broad with at least one area of depth.** They take expertise accrued in one domain and apply it in a completely new one. As information becomes more broadly available, the need for somebody to advance a field isn’t as critical because in effect it is available to everybody. Something analogous happened for

narrowly focused specialists in technical fields. They are still absolutely critical, it's just that their work is widely accessible, so fewer suffice. When information became more widely disseminated, it became a lot easier to be broader than a specialist, to start combining things in new ways. **As ambiguity and uncertainty increases, breadth become increasingly important.** Where length of experience did not differentiate creators, breadth of experience did. Individuals are capable of more creative integration of diverse experiences than teams are.

There is a "perverse inverse relationship" between fame and accuracy. The more likely an expert was to have his prediction featured on an op-ed page or television, the more likely they were wrong. [Foxes know many things but the hedgehog knows one big thing. Taken from Greek poetry]. Hedgehogs got worse as they accumulated credentials and experience in their field. They fit new information and story to their worldview. They make great TV.

In wicked domains that lack automatic feedback, experience alone does not improve performance. An hour of basic training in foxy habits improves accuracy. Hedgehog experts cherry-pick details that fit their all-encompassing theories. Their deep knowledge works against them. Foxes see complexity in what others mistake for simple cause and effect. They understand that most cause-and-effect relationships are probabilistic, and even when history apparently repeats, it does not do so precisely.

In the Good Judgment Project, volunteers drawn from the general public beat experienced intelligence analysts with access to classified data by 30%. Forecasters on the small super-teams became 50% more accurate in their *individual* predictions. The very best forecasts are like foxes with dragonfly eyes. They view their own ideas as hypotheses in need of testing. Hedgehogs tend to see simple, deterministic rules or cause and effect framed by their area of expertise.

NASA learned that the chain of communication has to be informal, completely different from the chain of command. "I will not intercept your decisions that belong in your chain of command, but I will give and receive information anywhere in the organization, at any time." A differentiated chain of command and communication produced incongruence, and thus a healthy tension.

We have people walking around with all the knowledge of humanity on their phone, but they have no idea how to integrate it. We don't train people in thinking or reasoning. Apprenticeships encouraged conservatism and stifled innovation. The system maintains you in a trench. You basically have all these parallel trenches, and it's very rare that anybody stands up and actually looks at the next trench to see what they are doing, and often it's related. Bring new skills to an old problem, or a new problem to old skills. Work that builds bridges between disparate pieces of knowledge is less likely to be funded or appear in famous journals, more likely to be ignored upon publication, and then more likely in the long run to be a smash hit in the library of human knowledge. All life is an experiment.

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