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Expertise:Novice Approach vs. Expert Strategy

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Humans have been fascinated with a job well done since the beginning of time. We extol our heroes. Those that triumph with skill and prowess we can't imagine possessing get passionate songs and epic poems written about them. We lift them high with our awe and place them on pedestals. We spend big bucks to see their concerts and faint when they pass near us in the crowd. We give them millions of dollars to bounce balls for a living and buy whatever soda is their favorite. We give them Nobel Prizes and save their brains in jars so 3rd year graduate students can perform experiments 60 years later. Experts are fascinating.

Experts are interesting in the way a circus is interesting. We recognize they have a *differentness,* a strangeness, an odd quality that separates them from regular (even highly intelligent) people. True experts specimens are a bit of a spectacle, inspiring admiration, appreciation, and a sense of wonder. Clearly, something separates them and makes them special. The true apex of our fascination might actually be reunderstood as this; "what is this quality of *expertise* that certain people are able to embody… and who is a candidate for it?"

Expertise, perhaps, is the truly interesting topic because it provides insight into the nature of thinking and problem solving. Studying experts isn't just about focusing on oddball outliers. It *is* about learning what highly successful learning looks like. According the Bransford, Brown, and Cocking (1999), to be considered an expert, one must, by definition, have developed particular ways to think and reason effectively, resulting in exemplary performance in a specific field. "Experts have acquired extensive knowledge that affects what they notice, how they organize, represent, and interpret information in their environments. This, in turn, effects their ability to remember, reason, and solve problems." This means experts' knowledge is not only magnificently organized, but exemplifies deep understanding on many levels.

Expert knowledge, unlike novice knowledge, is not a set of memorized facts, formulas, or procedures. Core concepts and "big ideas" illuminate their expert knowledge in their domains. Experts can utilize this vast repertoire of knowledge by conceptualizing many interlocking subsets of information and manipulate them at will in relevant ways towards resolving a given problem. Human experts can determine relevance, restructure knowledge, break rules when exceptions are appropriate, and, most importantly, experts are acutely aware of the extent of their abilities and limitations. If managers seek to improve attendance, raise engagement levels, and encourage the absorption of learning materials by their team, this is an imperative case study in the effectiveness of deliberate practice.

One of the primary superpowers experts seem to posses is the ability to find meaningful patterns amongst what other's see as noise. Recalling knowledge for experts takes little effort, and they are able to contextualize and glean information with apparent automaticity. Searching title by title through an entire library for the specific book you want would take ages, wasting time and energy. It may even reduce the likelihood of your return to the library to search for further information. However, an expert knows where their favorite section in their mental library is. They head straight to the right aisle, know where to find the shelf they want, can quickly identify the approximate location of their favorite author, and probably know the positioning or color of their most beloved books for easy accessibility. Further, they probably know which chapters in which books are good for what and, roughly, which sections of those chapters are useful right now. As Miller said (1956), "experts do not have to search through everything they know. Such an approach would overwhelm working memory."

At the heart of this automaticity (also called fluency) is a biological trail blazing called connectivity (Koether, 2003). Connectivity is the idea that nodes and networks exist within brain structures and cross reference each other as a result of experience and learning (Rajapakse et al, 2007). Major structures of the brain are organized in a pre-determined biological way (Shoenbaum et al, 2000). The hippocampus will always reside in the same place deep in the reptilian brain near the brain stem, be primarily responsible for memory, and visually, slightly resemble a seahorse. However, the ways in which various specialized centers in the brain "talk" to each other and thus give rise to our subjective experience is *highly* influenced by repetition (learning)(Toni et al, 2002).

Certain cues will strengthen certain relevant connections (for example, intense emotion, such as it fear or euphoria), making the route between those connections more automatic, immediate and experienced subjectively as “truer” (Morris et al, 1998). This fluency feels like part of true self because we’ve literally carved the tendencies (paths between nodes) ourselves, with repetition and energized action over time (Büchel et al, 1999). This can be imagined like a path developing where feet have tread many times in a forest full of undergrowth. Eventually, obstructive foliage will be stomped away, interferences and unused deviations pruned, and the path will become clearer, easier, and more automatic to traverse. This fluidity strengthens connections between regions of the brain, resulting in strengthening of understood concepts, beliefs, and behaviors. This offers higher processing speeds, cross-referential pattern recognition, and other markers of cognitive and behavioral fluidity (Huang et al, 2009).

Connectivity works like a virtuous cycle. The more pathways are utilized, the more they demand attention and grow stronger (Neath and Surprenant, 2003). In the same way a runner’s legs love to be stretched, neurological networks call to be flexed as well. Because learning is biologically driven and evolutionarily selected for, the most developed systems we’ve cultivated will itch, consume our attention, and we will seek the pleasure biologically driven from scratching it (Tulving and Craik, 2000). In novices, this biological itch could represent anything, probably a disparate and non-conscious assortment or biases and ill-begotten behaviors. Experts, however, typically excel in a narrow domain that they’ve cultivated with immense discipline consistently over long periods of time. This physiologically enhances biological structures allowing for impressive fluidity and innovation (Weiss and Shanteau, 2012).

The more connectivity (neurological real estate) a domain has claimed in an expert’s brain the more effective their retrieval and problem solving will be. Retrieval can range from “effortful,” “fluent,” or ideally, “automatic.” (Schneider and Shiffrin, 1977) This is essentially muscle memory, but in terms of neurological connectivity. Fluency is important because it takes less energy or effort, and the amount of information a person can process and attend to at one time is limited. (Miller, 1956). The less attention one aspect of a task is allocated, the more attention is free to be allocated to other aspects of the task. (LeBerg and Samuels, 1974, Anderson, 1981, Lesgold et al, 1988). The more attention an expert has available, the more innovative and exacting they can be when performing a skilled act, determining relevance, restructuring knowledge, and employing appropriate exceptions.

As infants, our brains have many more connections than we need, connecting every structure to every other structure, just in case (Riem et al, 2012). For example, infants can identify any phoneme from any language, including tonal ranges in tonal languages (Bliele, 2004). As infants mature, the phonemes and specific articulations not reflected it the surrounding environment are pruned away, making room for more important connections. The result is that certain sounds are pruned away and not even *heard* by adults utilizing other languages. It will be difficult or nearly impossible (especially when first trying) for an adult westerner to differentiate between sounds in a multifaceted tonal language, and often speakers of some Asian languages can't hear the difference between and "r" sound and an "l" sound. We were all born with the capacity to learn any language, but neurological real estate is our most valuable asset and underutilized connections are pruned away and reallocated to more frequented nodes and networks.

Experts see pattens where others see noise. All people use shortcuts when processing information. This is a necessary foundation of human functionality. Experts have managed to harness this capability and utilize short-cut tendencies (heuristics) in their favor. Novices and experts alike use pattern recognition, as this is the cornerstone of human thinking. The difference between the two is the effectiveness of each strategy. Chunking is a heuristic in which long strings of data are grouped together into more meaningful "chunks" (Miller, 1956). For example, when we recite phone numbers, we tend to do so in three or four digits at a time. When we meet new people, it helps to link their face with their name and a fact or two about them that will improve saliency in the future. This helps information last in short term memory longer, increasing the potential to develop necessary information into long term memory (Neath & Surprenant, 2003, Tulving and Craik, 2000).

In one study, master chess players and novices alike were asked to think out loud as they played and strategized. Interestingly, experts were not necessarily quicker to answer. Novices, in general, will to try to jump directly to a solution. Experts tend to take more time to understand and evaluate solution strategies (Csikszentmihalyi and Getzels, 1976). In Degroot's famous 1965 study, expert chess players' articulated strategies led the research team to the conclusion the quantity of strategies articulated wasn't considerably higher than novice chess players, but that the *quality* of the experts' strategies was superior. This reflects that the much deeper levels of connectivity afforded to experts allows accurate, faster, and more dynamic information processing and retrieval. Even if they novices and experts state equal numbers of potential moves, and even if experts aren't the speediest responders, the quality of their perceived options is of a much higher caliber than novice attempts.

The movie Field of Dreams popularized the phrase "build it and they will come." This is the benefit of building calculated connectivity with deliberate learning, as experts do. When brain structure is strengthened and connections are paved, the roads are easily, quickly, and efficiently traveled, allowing more comprehensive problem solving and the creation of novel innovation.

All human beings rely on heuristics to navigate a world of endless stimuli, data, and demands. Experts are able to sift out noise from importance, at least in their specific domain. Novices are subject to many heuristic fallacies, and managers would benefit from knowing how individuals fail. The certitude that comes with reliance on heuristics may be convincing, but when the bottom line is at stake, these traps should be recognized.

Often, when one isn't trained (or isn't trained enough), they'll grasp for meaning amongst perceived familiarity (Hubscher 2016). In machine learning, there is a term called "overfitting," describing what happens when a statistical model fits the noise in a data set rather than the signal. Attention is payed to outlying information instead of focusing on generalizable patterns that fit more representative data. Said differently, assumptions or problem solving are aimed at the wrong parts of given information. This is also known as the Gambler's Fallacy, and leads people towards erroneous conclusions and behaviors (Ayot and Ilan, 2004). Michael Sheerer coined this term as "patternicity" in 2008, describing it as "the tendency to find meaningful patterns in meaningless noise (Shermer 2011). This is also known as *apophenia,* or the human tendency to see meaningful patterns within random data (Brugger, 2001).

Pareidolia is a subtype of apophenia involving false pattern recognition of images or sounds in random stimuli (Syoboda 2007). Perceiving faces is an example humans are very well appointed for biologically. Seeing a religious figure on a piece of toast, identifying the "Man on the Moon," or seeing other "grinning" objects, or even hearing your silent phone ring over the noise of your shower are examples of pareidolia (Waterstone, 2007, Aaron 2010).

Since learning is biologically driven, can we conclude that expertise result from genetics? Is expertise a "gift?" Do these experts have natural born "talent?" Perhaps the more interesting question here is *why* do people expect that great prowess comes only genetically? Over 40 years of expertise research has been executed, and according to a leading scientist in the field, “at present, no one has shown any clear and compelling evidence that having certain genes (outside of hight and body size) is necessary to attain elite performance in a particular field.” (Anders Ericsson) blogs.edweek.org/.../peak_an_interview_with_anders_ericsson_robert_pool.html

How can this be? What about child prodigies? Aren’t there instances of certain special people who just emerged fluent and remarkable in their field? Take Mozart, for example, the prototype of prodigies. He was composing symphonies at age six! Surely this is proof of “god given” blessings, bestowed upon the lucky and withheld from ordinary folk. What most people don’t know is that Mozart’s father was a composer, fairly accomplished musician, music teacher, and rigid task master himself and music teacher. According to some reports, he forced Mozart’s practice for 12 hours a day as soon as Mozart could sit at the piano and hold a violin. Mozart had famously perfect pitch, a trait widely believed to be genetic and impossible to teach. However, we do know something about Mozart (and his siblings) training. His father taught each of them four short lessons every day, lasting only a few minutes, in which he would focus on a single note at a time. The children were expected to practice this note using varying methods on various instruments until they could recall it perfectly from memory when tested by their father amongst other notes. When Sakakibara tested children in similar conditions in 2014, *every one* of the children had learned the notes perfectly within a year to a year and a half. Thus, through purposeful practice in a meticulously structured learning environment, they acquired perfect pitch. The ideas that certain people are “gifted” ignores and discredits hard work, strategy, and determination.

Basketball legend Ray Allen has famously argued agains this prevalent bias (Filippi, 2011). He takes offense to the constant commentary he is faced with as people attempt to compliment his “innate” precision and beautiful jump shot. ““It really pisses me off. I tell those people, ‘Don’t underestimate the work I’ve put in every day.’ Not some days. Every day. Ask anyone on my team with me who shoots the most. The answer is me.”

What does this mean for managers? To begin with, this news should be a relief to all who read it. If expertise is trainable, if solid learning is formulaic, then the opportunity is on the table for all. Managers can conclude that purposeful training can and should be implemented (Fernandes, 2005). They should be able to identify their team and the work they do as focused or unfocused, structured or unstructured, progressing or stagnant. Just because employees have been doing things the same way for years does not make them experts at their tasks, or the world would be shoulder-to-shoulder with amazingly skilled people. Many people perform an action every day, and few have reached levels of mastery in the domain in which they participate. If 10,000 driving hours is all it takes to be an expert at it, speeding wouldn't happen, everyone would use their blinkers, and accidents would be nearly unheard of.

Malcolm Gladwell famously popularized the so called "10,000 Hour Rule," which is the idea that to yield expertise from a subject, all it takes is a stick-to-itiveness that, on average, blossoms at around 10,000 hours (Gladwell, 2013). What this fallacy ignores is that the utilization of passive methods will never give rise to exceptional behavior - not at 10,000 hours and not at 100,000 hours. This is why a driver in their 50s may not necessarily be a better driver than they were in their 20s. Most people in most situations don't apply deliberate practice, but instead are passively "going through the motions," so to speak. Mindless reputation is not the kind of practice that leads to ground-breaking expertise.

For example, many athletes tend to "zone out" during repetitive movements, especially in sports such as long distance running or swimming. Most athletes (understandably) spend their time overcoming the monotony of "step, step" or "stroke, stroke" by daydreaming, distracting themselves, or otherwise thinking about pleasant objects. In contrast, the most elite athletes remain "in their bodies" and focus on moment-by-moment perfection of technique and form with full concentration and focus, right down to each individual breath.

In a Swedish study, although both experts and novices reported feeling more relaxed and energized after a singing lesson, only novice singers reported feelings of elation. Where novices were simply expressing themselves and enjoying the music, experts were too busy considering factors of timing, vocal quality, and technique. This full concentration and focus has been well researched and is known as in the literature as mindfulness (Khoury 2013, Jha et al 2010). Mindfulness encourages the development of strong mental representations (Bishop, 2004), allowing fluidity of mental simulations, perceptions, and projections, as well as finely tuned physical skill. Mindfulness assists in skill development because the utilizer will be acutely aware of their form and their edge, allowing them to push their boundaries past stagnation and onto deep learning. This deliberate endless cycle of reaching, failing, reaching, succeeding, and reaching yet further again is the ladder of success that experts climb. This iteration is made possible with mindful attention towards what experts call *deliberate practice (Duviver et al, 2011, Ericcson et al, 1993)*.

Many studies have shown that task performance is highly susceptible to improvement with the implementation of *deliberate practice.* Some of the most notable work in the field was executed by Carl Wieman and his research group in 2002. Dr. Wieman won the Nobel Prize in physics the year before and had created two groundbreaking organizations called the Physics Education Technology Project at the University of Colorado and the Carl Wieman Science Education initiative at the University of British Columbia. His Nobel Prize winnings went to good use as he dedicated his resources to understanding and implementing a new way of teaching science to students (Deaslauriers et al, 2011).

At the the University of British Columbia, 850 undergrad engineering students taking a physics course were divided into groups. Over the course of the term, some participated in they class as usual, with the usual highly motivated and experienced British Columbia University professor as they expected, and others were in class taught by two graduate assistants from Wieman's labs with thorough physics training but barely any teaching experience, with zero experience leading a class. However, these far less experienced graduate students had highly well-defined and research-driven teaching methods that embodied deliberate practice. They had an empirically supported platform to stand on and a standardized method that was highly adaptive.

Unlike the traditional method involving a lecture followed by homework, and midterm, and final, the deliberate practice group was purposefully interactive and aimed at teaching the students to not only memorize facts and figures, but also to think scientifically and at a higher level, regarding concepts often deemed too difficult for first year undergraduate students. By opening up these questions to small groups, collaborative answers could be developed and then posed to the whole class for multi-level discussion capped by resolving the true answer, finally provided by the research instructors.. The aim was to allow students space to draw connections, think about concept, and see a bigger. By opening up group questions to the class and then answering them for everyone's benefit, ideas many might not have considered could be pondered and resolved in a satisfying way. Rather than being fed information, they were being taught to think like working physicists.

Another difference between the groups was the method of reading instruction. Instead of being given one or several chapters, which could be dozens or hundreds of pages to read before a traditional lecture, the research group was given only a few pages of key concept reading to complete before class, as well as a quick online true/false test based on the material help them asses their engagement and recall, indicating if further preparation (a rereading) was necessary. With all students familiar with the day's offerings, they had a foundation to build upon, questions to clarify, and a sense of purpose from the get-go. They weren't faced with a mind-numbing collection of pages to sort through, just an indication of the necessary take-aways designed to instigate curiosity, open communication, and develop habits comparable to an accomplished expert physicist.

Key concepts were tested for in the research group with multiple choice electronic questions to the individual, and those showing lower scores would be addressed in a mini-lecture to cover less understood materials. By providing immediate feedback, students could correct erroneous understanding with the help of their peers, instructors, and available materials. They were taught to understand the question in a meaningful way, consider which available concepts were applicable, and then use reasoning to arrive at a probable answer. At the end of the term, both groups were assessed in a test that had been developed by the research group and traditional class instructor. Once the standard learning objectives had been measured, average scores were tallied with surprising results.

Although the research team anticipated favorable findings, they were not prepared for the astounding results they were about to quantify. At first glance, the average score of the research group's class seemed substantial enough to qualify a landslide win, as their class average score was 74 percent, versus the traditional class' average score of 41 percent.   However, when one considers that chance itself would have dealt an average score of 23 percent on the multiple choice assessment, and that the research group's average was around 66 percent right answers, the difference becomes even more astounding. This means students engaging in deliberate practice were correct 2.5 times more frequently than the traditional group.

Statistically speaking, we could consider this difference in terms of the effect size. These two classes differed by 2.5 standard deviations in performance. Science and engineering classrooms have utilized a myriad of teaching practices and learning formulas, but on average, these typically have effect sizes of less than 1.0. In previous studies, effect sizes had even been shown to reach as high as 2.0 with the utilization of specially trained tutors for the individual (Ericsson, 2016). This study achieved an effect size of 2.5 with predominantly untrained teachers who, nearly blindly, administered prescribed methods of deliberate practice.

The question remains: How do learners feel about being trained using these methods? When students were asked to asses their experience in the research class, 90 percent of the respondents agreed that they enjoyed or strongly enjoyed it. 77 percent of the respondents agreed that “I feel I would have learned more if the whole physics 153 course would have been taught in this highly interactive style.” Students not only enjoyed the course, but they felt they had learned more and would prefer to learn this way in the future. According to Science Magazine years later, nearly one hundred science and mathematics courses accounting for over thirty thousand students adopted Wieman’s deliberate practice based approach, despite the fact that math and science professors are traditionally highly resistant to alterations in their teaching methods (Kagan, 1992).

The major difference between traditional methods and the concept of deliberate practice lies in the focus of learning: traditional methods focus on memorization of facts, figures, definitions, and other points of knowledge. Knowledge is accumulated and collected like so many berries in a basket, and it is generally assumed the learner will, after collecting enough berries, have an epiphany spontaneously develop the ability to bake a delicious pie. Deliberate practice emphasizes skill over knowledge, with the assumption that if you endow a learner motivation and context, the knowledge will be a bi-product. For example, a fun and engrossing cooking class doesn’t ask students to bring their own ingredients to their workshop. The class provides everything one might need for the exercise and students are sent home with nothing but their experience and burgeoning skill. They must then go out and buy their own ingredients to recreate the experience, with every possible choice provided by a grocery store available to them. They must utilize their own mental representation of the process to prepare, recreate, and asses their ongoing efforts.

These mental models open the door to the exploration of skills and concepts on one’s own (Arrow, 1971). An individual can see how pieces fit together to assemble a whole. Variations become improvisational tools and focal filters to continuously asses, reassess, and expand one’s own burgeoning or existing expertise. With a quality mental representation, individuals are no longer tethered to teachers for each incremental improvement, but can begin exploring and conquering some routes on their own (Jackendoff, 1995). Essentially, the key to managers who want to encourage effective learning and develop expertise among their team is this: the enduring cycle of repetition, feedback, and deliberate development of mental models should keep individuals at the edge of their comfort zone, but not so far outside it that they cannot master each incremental step.

Managers can encourage the development of expertise amongst their team is by encouraging and motivating process approaches with focus on deliberate practice. Going through the motions will never result in the development of expertise, though in certain instances, like physical tasks, the best case scenario might result in a lower-level muscle memory (Larsen-Freeman, 2010). Even shooting 1000 free throws doesn't guarantee the result of better form. To improve to expert levels, the improvement must be consciously maintained at the forefront of mind. Critical insight can be invaluable to problem solving in an endeavor or organization, and training managers would do well to staff their team with those adept at mental modeling.

There are two ways managers can cultivate such a commodity in their organization. Firstly, they can encourage mental modeling and behaviors that lead to the development of mental representations on their existing team. By utilizing cornerstones of deliberate practice (Big Picture integration, collaboration between peers and experts - even mechanical ones, and iterative significant but surmountable challenges punctuated by timely feedback), the development of accurate mental representations can be fostered (Ericsson, 1993).

Secondly, hiring managers can look to those already accomplished in the cultivation and nurturance or mental representations as valuable additions to their existing team. They should ask questions designed to elicit meaningful patters recognition and configuration, as experts will quickly understand their implications. As Branford and Brown put it (1abstraction has been replaced by perception. However, mental representation development is not specifically a goal in current educational systems. Thus, especially amongst younger candidates, hiring managers might seek those with well developed extracurricular activities, such as accomplishments in sports or music. Although these domains might seem disparate from the hiring organization's goals, the commonality among the most successful performers is the development of mental representations, and the benefits of this kind of thinking stretches across fields. These candidates will have experience seeing how different parts fit together to create a unified whole, how variations effect the bottom line, how boundaries might be expanded willfully and dutifully, and how unknown factors might be manipulated and experimented with to incrementally attain a depth and breadth of knowledge that could easily seem daunting or unattainable to those lacking this systematic approach.

It has even long been reported that mental representations may be the seat of self awareness or consciousness all together (Johnson-Laird 1983). Theory of Mind is a term referring to the ability of humans to make assumptions about the mental states of others (pretense, desire, intention, knowledge, beliefs, etc) and understand that they may differ from one's own (Leslie, 1987). This allows for fluidity in social situations based on correct understandings and appropriate actions (Korkmaz, 2011). Whether or not this ability is extended to certain intelligent species such as corvids and chimpanzees remains a highly researched topic (Premack and Woodruff, 1978). We know that in humans with schizophrenia, autism spectrum disorders, alcohol toxicity disorders, and attention/hyperactivity disorders this can be partially or entirely absent (Uekermann, 2008). Accurately reflective mental representations benefit the individual because they understand what is possible and how to make it happen. This is why experts in one domain will often have high appreciation for experts in other domains. They understand the sacrifice, determination, and strategy it takes to succeed in a particular field.

It is important for managers to understand the importance of adaptability and deliberate, meticulous, and iterative skill development. They must be able to arrange for positive feedback. Positive feedback does not mean congratulations for a job well done, it means introducing an element that increases the likelihood of the desired behavior. This can be timely performance reviews with enhanced specificity and well developed next steps, programmed learning modules that demand comprehension before allowing further progression, or other interaction with other expert sources, such as expert systems (Emurian, 2007).These systems can capitalize on deliberate practice, if/then scenarios, and instant feedback. Areas of weakness should be determined and specific action plans with detailed next steps should be administered (Emurian 2009).

This should be of paramount importance when designing technology, or programmed instruction, to assist learning in novices and experts alike (Emurian 2008). Technology should emphasize questions and situations that not only test understanding of key concepts and methods, but also provide feedback that is customizable based on a matrix of factors. This feedback should be as immediate as possible and learners should be afforded the opportunity to repeat the procedure until they can automatically find correct answers with little effort.

Learning machines were developed and popularized in the 60's by pioneering behavioral psychology B.F. Skinner. He believed reinforced learning could be designed to affect motivation and higher-level retention in learning. Skinner, being a behaviorist, believed in the power of learning by *doing* (Skinner and Holland, 1961). However, in a world that never has enough teachers or enough training, he decided to develop something that any learner could use any time, with or without access to a specially trained human instructor (Skinner, 1961).

Programmed instruction was developed to assist learners at any level in any domain . The benefit was automatic, immediate, and regular learning that was both adjustable and adaptive to each individual. Speed was personalized, and material presented was coherent, but also novel and varied. Multiple choice questions would be administered, with choices varying as weaknesses in knowledge were discovered and repeated until the learner could identify the correct answer in varying scenarios, demanding a true competence and not simple memorization with potential comprehensive failures (Skinner, 1965). Skinner's learning machine, GLIDER, would only proceed to new questions and topics after current examples were mastered. The foundations of programmed learning are broken down in the following components:

1. The aims of the course are stated in terms which are objective and measurable.
2. A pre-test is given or initial behavior is assessed.
3. A post-test is provided after the base level is determined.
4. The materials are revised according to results (developmental testing).
5. The materials are constructed according to a predetermined scheme (stimulus control).
6. The material is arranged in appropriate steps.
7. The learner has to respond actively (not necessarily overtly).
8. Responses are confirmed (knowledge of results).
9. The teaching medium is appropriate for the subject-matter and the students.
10. The materials are self-paced or presented in a manner which suits the learner.

This has become a standard of programmed learning, as seen in best selling computer assisted instruction, such as typing software (Mavis Beacon), popular children's tv shows (Blue's Clues and Sesame Street), the LISP scheme learner (Little Schemer), The Saxon Method mathematic trainer, Bobby Fisher Teaches Chess, and United States Air Force training software (Fischer et al, 1966, Hayes 1992, Friedman et al, 1996, Tracy 2002, Anderson 2000). Skinner also paved the way for other forms of programmed learning, such as *open learning* (a widely used teaching method, most notably found in Montessori schools). In this method, students are actively engaged, attentive, and interested, and effectively learning the desired behavior. This method effectively capitalizes on the deliberate practice key concept of “learning by doing.”

This is an important distinction: knowledge and skill acquisition are different objectives. Knowledge is traditionally the focus of development of expertise. Typically, information is provided and the employee or student is assumed to take responsibility for knowing how to apply that knowledge. However, if neurological connnectivity gives us any clues, we know that connections are formed more strongly when certain emphasis exist. Most notably, people learn quickly through strong emotions (such as fear leading to heightened aversions or phobias), and physical cues (repeated movements becoming fluent and fluid as muscle memorydevelops). Activating these cues seems to lead to faster and deeper learning, or, more effective connectivity. Skill requires the utilization of knowledge, the input of data and application of knowledge toward a longer term goal of wisdom. This application of knowledge is similar to reading about riding a bike versus actually riding one. Individuals may vary in terms of fluidity between mere confrontation of data and it’s potential to develop into wisdom or expertise, but this application of a “doing” action is well supported in research as of paramount importance for managers interested in activating higher learning in their organization.

The communication of knowledge and relative ignoring of of skill development has long been a pervasive problem in educational settings, particularly in the case of medical students Duvivier et al, 2011). There is a famous saying in medical school illustrating this take on learning medical procedures: "See one, do one, teach one." Meaning, the assumption is that it is enough to see a procedure done once to accurately execute the procedure. This assumption springs from emphasis on knowledge rather than skills. However, when patient outcomes have been measured in research, surgeon performance has shown to improve steadily as a direct function of the number of completed procedures. This is true of the first 50 to 150 surgical procedures a surgeon performs.

Therefore, it is nowhere near enough to just, *conceptually* know how to perform a surgery. Surgery is a skill, and skills must be developed through practice. Increasingly, negative consequences for patients from doctors learning on the job is being minimized by utilizing the programmed learning Skinner introduced with his GLIDER learning machine. Extensive training is more frequently required of medical students by utilizing computer simulators, and once this has been mastered, early surgeries are assessed under the supervision of experienced surgeons. Because of programmed learning and medical student access to computer simulations, patients can typically expect to get excellent care from all surgeons, even those that are “green.”

The training of managers could be similarly improved by designing computer environments where managers could get immediate feedback on their ability to make their organization an effective learning environment and on how well they diagnose the problems of individual employees in order to help them flourish and continue adding value. Employees and managers alike would benefit from learning environments in which immediate feedback could be received on their actions and reactions (Dimmock and Walker, 2004). Learn from their mistakes in this way would allow correction in a simulated environment, leaving the workplace less error-prone.

The primary benefit of programmed learning is that assists with the development of mental representations, the cornerstone of learning like an expert. Much as we can imagine having a photographic memory might be valuable, having a mental representation allows us to take a better look at the information we desire mastery over. This allows an individual to guide their own performance, as they’ll have a clearer vision as to the topography of their own knowledge. Without this, accurately knowing the next peak to ascend can range from challenging to impossible. With this map and deliberate practice, a virtuous cycle can lead to expertise and sustained successful learning (Jones, 2003). Sharpening of a mental representation allows sharpening of skill development, and eventual expertise.

According to one of the world’s leading expert on experts, Dr. Anders Ericsson, one of the most important ways to help students become motivated is to encourage their ability to think and reason independently so that they can eventually take control of their own practice and performance (Ericsson et al. 1993). He is referencing to the development of a tool known as mental representations. Rendering accurate mental representations affords the opportunity to think dynamically. Creation of mental models or representations that become tools and expert can utilize psychologically at any time, vs. only in person in action. The difference is that mental models allow for a dynamic approach to problem solving, whereas knowledge accumulation alone reads like a long list of items that are much harder (and slower) to sort through and make sense of. (Wieman)

The most successful learners can think about their own thinking. This metacognition allows them to understand their limitations and thus know their growth opportunities. Even experts can gain further expertise, and in fact have laid the foundation for an ever expansive virtuous cycle, so long as they remain aware and open to this depth and breadth of new understandings. Much as children often erroneously believe they will recall new information at will and fail to employ effective learning strategies (such as rehearsal), novices are more likely to misjudge their own opportunities for learning (Brown 1980, Flavell 1985, 1991, Glaser 1992).

The “learning by doing” approach and the imperative mental representations that accompany it are woefully absent from continuing education structures for doctors and medical professionals as well. Their continuing education typically entails going to huge conferences, sitting in a sea of audience members and watching a Power Point, with the expectation that the professional “expert” now has all the tools to implement this information into their own practice and improve their performance. Surgeons have been particularly well studied. Research reflects that simply listening to lectures does little to nothing to improve a doctor's performance, as assessed by how well the doctor's patients do (Fox and Bennett, 1998).

Whether training is implemented by computer systems or other experts themselves, there is an important fact to keep in mind: expertise does not equal articulative capacity or gift for instruction. Articulative capacity may even be a form of its own expertise. With this in mind, it follows that experts in an organization may not necessarily the best trainers of others.

Further, expertise is not synonymous with adaptability, even within the same domain. Experts vary on their ability to succeed under new parameters in new situations. In 1986, Hatano and Igaki identified two kinds of expertise: adaptive (flexible), and fixed (routinized). According to Miller, 1978, this problem exists across a myriad of jobs, including systems design. The US army has spent a considerable amount of taxpayer dollars to gain insight in what they call “adaptive thinking,” especially amongst higher-ranking officials who work on the ground in volatile situations in which hundreds or thousands of lives are at stake and outcomes from on-the-spot decision making is critical (Raybourne, et al, 2005). They even implemented a “Think Like a Commander” program in order to enlighten junior officers with deliberate practice towards adaptive expertise.

Many studies have been performed to illuminate the concept of adaptability and how to best train for it (Okazaki et al 2005, Miller et al 1994, Gigerenzer 2000, Raybourn 2005, Ross and Pierce, 2000, Kozlowski 2001). For instance, it has been shown that while practicing very specific parameters in task execution can lead towards mastery under those parameters, it may not generalize to other parameters, even those that are very similar. For example, when research participants were tested on accuracy of ball throwing, those that practiced with only one size and weight of ball aiming at a single distance were effective at succeeding only with the familiar ball at the familiar distance. They were, however, unable to be more accurate than average at other sizes, weights, and distances.

Participants that practiced with varying balls at varying distances over time were more accurate holistically, regardless of parameters, even when faced with previously unpracticed size, weights, and distances. They had been trained to be adaptive, or open and successful in new experiences. Managers attempting to turn employees from novices to experts or simply encouraging successful learning should consider these studies in adaptability. Even if an employee's tasks are expected to remain unchanged, training under varying parameters will allow cognitive and behavioral flexibility when the unforeseen occurs (Gilbert 1991, Gilbert and Wilson, 2007). In this way, remaining open and successful in new experiences is absolutely trainable.

Managers wanting to improve learning and increase expertise on their teams will do well to implement effective training systems and simultaneously encourage adaptability (Bell, 2008). A concept that can greatly effect employee engagement and absorption is one Dr. Mihalyi Csikszentmihalyi coined as *flow*. This is otherwise known as The Zone, or the mental operating state characterized by achievement in which a person is actively engaged, brimming with energized focus, and fully immersed in the task at hand. Gamification is an example of systems designed to encourage flow. Information is presented in small chunks, iterated, and rewarded. Even small wins serve to maintain or increase motivation, and motivation keeps employees engaged and available for flow-like levels of concentration. Flow is important to the workplace because it yields higher productivity, innovation, and employee development (Csikszentmihályi, 1990, 2004).

Flow is an intrinsically rewarding state of persistence that can improve the workplace with higher satisfaction and accomplishment. Csikszentmihalyi puts it best, "Imagine that you are skiing down a slope and your full attention is focused on the movements of your body, the position of the skis, the air whistling past your face, and the snow-shrouded trees running by. There is no room in your awareness for conflicts or contradictions; you know that a distracting thought or emotion might get you buried face down in the snow. The run is so perfect that you want it to last forever."

This sounds amazing, but how can managers implement it? According to Stefan Groschupf for Harvard Business Review, active engagement and learning can be dramatically increased in an organization by implementing practices designed to encourage and activate flow in teams and individuals. When interruptions are minimized, improved concentration and motivation yield better performance. Engaged employees love the experience and feel fulfilled in their jobs (Jiamao 2010, Payne 2005). Interruptions should be minimized organization wide, not at the individual level, to create an environment that nurtures flow and the benefit it reaps. Managers should allow people to periodically switch off email, have fewer meetings, and work at smaller project chunks. The concept and goal of flow and engagement must be clearly articulated to employees, as well as the importance and expectation of finding ways to attain them. Challenge and reward cycles should be frequent, visible, and uninterrupted. This growth towards complexity cultivates quality employees and encourages learning and expertise development.

The implementation of flow in the workplace should follow three conditions. First, goals should be clearly outlined. Second, feedback should be immediate. Lastly, there must be a delicate balance between opportunity and capacity (meaning it should be difficult, but not too difficult. The stretch should be appropriate and challenging without being so difficult that motivation suffers. Often, organizations do a terrible job of fulfilling these conditions. Employees often don't know how their specific tasks fit into the overall picture, making their own work seem unimportant. Without communication, they may be assigned tasks in which the challenge is not high enough or is too high, resulting in dissatisfaction, boredom, anxiety, and lower engagement. Frequently they do not receive feedback of how their tasks specifically affected the bottom line, or receive limited feedback, resulting in reduced motivation (Csikszentmihályi, 1990). Managers have many tools at their disposal to encourage learning and develop expertise on their teams. Managers can implement flow-encouraging workplace practices, train and assess employees using programmed learning, coach specifically for adaptability, work to create strong mental representations , encourage metacognition to illuminate the way each individual relies on heuristics, and above all, extol and model the key to learning: deliberate practice.

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