The Ecosystem of Learning. . . . . .Anything

Speaking Notes

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". . .optimizing instruction will require unintuitive innovations in how the conditions of instruction are structured."

-Drs. Bjork and Bjork

What Are Your Goals?

- To learn to teach well.
    - Teaching is something that if done poorly is barely done at all and can be potentially damaging to the development of a person. I know we are not paid like it, but we are as important as doctors. Think of it this way – someday your students are going to be in Congress making decisions about your retirement, important social and moral issues, or heck, just get along and get a few things done. Will you contribute to your student's growth in a way that supports them making the right decisions when it is time?
- Teaching is a no fail job.
    - Doctors, pilots, lawyers, etc.
- Resistance to change
    - For the same reasons your kids don't want to do homework, and parents fight you when you are trying to do good things for them
    - You don't have to believe me, but it is your obligation to figure out if this stuff works the way I say it does.
        - I'm here to save you time, but please, please do the work and decide for yourself
- Believe it or not this is just the tip of the iceberg. What you hear today are just jumping off points for more investigation, so as much as there is, there is much more to understand in order to implement this stuff.

Teachers are Brain Surgeons, Literally

Webster online

Full Definition of surgery

plural surgeries

1: a branch of medicine concerned with diseases and conditions requiring or amenable to operative or manual procedures.

- We are literally brain surgeons. While it is quicker with a scalpel, we use cognition to change student's brains and we do it in very specific ways depending on the subject.
- We know how to build our biceps, and are not surprised when they get bigger with exercise.
- It just takes a long time for the necessary large-scale neurobiological changes to occur. We easily accept this with our bodies. If someone decides to start working out and eating well we know that, over time, their body will gradually change. Even if they are very dedicated we know there will be little change in a few weeks.
- And that is just normal everyday life. Think about the level of training needed for the different levels of athletics. Now think of the cognitive training beyond regular competence for high educational performance.
    - BTW this is the exact model we use for giftedness education. Why should this be special?
    - Neuroplasticity

Learning Happens in Your Brain

- Neuroscience has improved dramatically over the last 30 years. The advent, and more importantly improvement, of fMRI (Functional Magnetic Resonance Imaging) as well as other diagnostic tools have pushed the field forward at an astonishing rate.
- It is enlightening the best cognitive/educational psychology has brought to bear since the middle of the 20th century or so (and more really). Seen as part of that big picture there are exciting things to learn about how we learn, and many of them are quite counterintuitive.
- Everybody has some of this, the great teachers have most of it, but few know the terms and how these concepts are organized as part of a larger model. This is because the research has only recently been disseminated and those of us who teach are, understandably, very far removed from the field of cognitive and behavioral psychology and neuroscience.
- Neuromyth
    - "The popularization of neuroscientific ideas about learning – sometimes legitimate, sometimes merely commercial – poses a real challenge for classroom teachers who want to understand how children learn. Until teacher preparation programs are reconceived to incorporate relevant research from the neuro and cognitive sciences, teachers need translation.. . . Meanwhile, the success of our schools will continue to be narrowly defined by achievement standards that ignore knowledge of the neural and cognitive processes of learning. . .these naïve misinterpretations of science have spread throughout the folk psychology of educators in recent years. . .The problems facing scientists and teachers are only exacerbated by the popular media, particularly those who sensationalize the, "Bold new findings," of scientists and exaggerate their immediate impact on society. . .An exchange of knowledge between neruo- and cognitive scientists and educators will help generate a better understanding of how learning takes place in real-world contexts." (Hardiman et al 1, 3)
    - "The need for translators and for greater collaboration between educators and neuro- and cognitive scientists has been previously described by a number of researchers [Ansari and Coch, Fischer et al., Hinton and Fischer, Kuriloff et al., Ronstadt and Yellin]." "These translators, trained in multidisciplinary programs tied to school of education, can return to schools and school districts with sufficient background in the neuro- and cognitive sciences to provide perspective and transmit knowledge to their colleagues." (ibid 3)

- Do we really only use 10% of ou brains?

THE CAMBRIDGE HANDBOOK OF EXPERTISE AND EXPERT PERFORMANCE

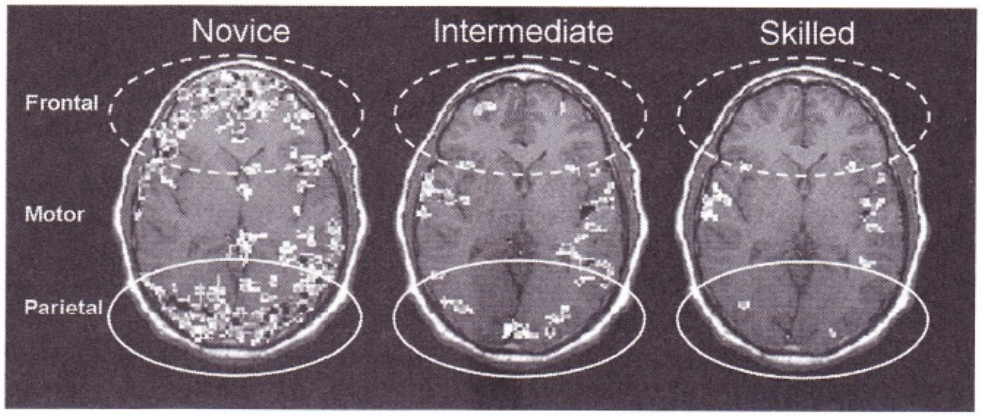
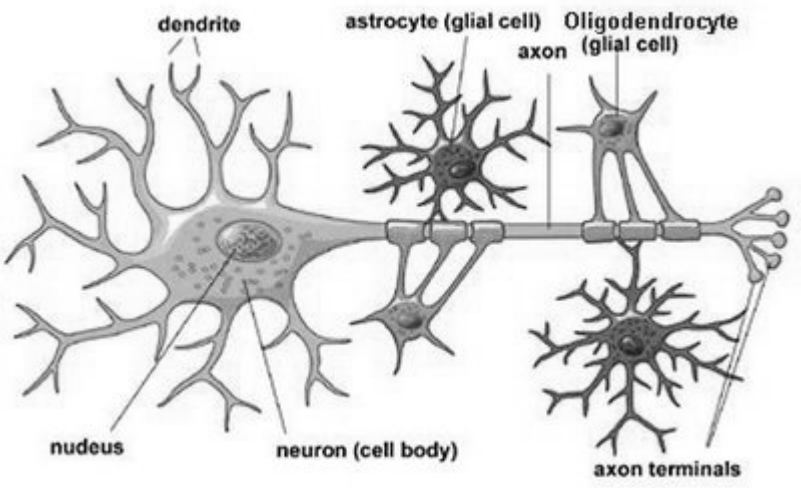


Figure 37.1. Activation of the brain, as a function of practice, in three periods of learning a motor tracking task. This is a maximum projection image, with white areas showing the activation of any cortical area either above or below the illustrated brain slice. The image is an axial (aerial) view of the head, where the top of the image corresponds to the front (nose) of the head and the bottom corresponds to the back of the head. The frontal areas (dashed ellipse) and parietal attention control areas (solid ellipse) show dramatic reductions in activation. The motor areas (middle of images) shares fairly preserved activation.

- Process Efficiency Change (Hill, et al.) – less is more
    - During this process the brain is working through confusion to find the perfect efficiency point for that task. (See the fMRI images on page 2). This occurrence has been called a process efficiency change. (Hill and Schneider)
    - At first the brain it is lit up like a Christmas tree. Most notably the pre-frontal cortex, responsible for executive function, is very involved. As the task is learned more and more regions drop out as the brain finds the perfect efficiency point for the desired ability. Here the skill can be reliably executed. This process involves difficulty and frustration as the brain is trying to figure out how to best deal with it.
- **Just as we can lift weights** in order to change and strengthen our muscles so too can we engage in exercises that physically and/or functionally change the brain. (Doidge)
    - Violinists left hand representations, London cab drivers Hippocampi. On and on.
- This is the idea of neuroplasticity. A concept that some still find hard to believe.
    - The book, *The Brain That Changes Itself*, follows the transition from the old thinking of specialization in the brain to our current understanding of how we can change it by the choices we make. (Doidge).
    - The old ideas that the brain is done evolving after childhood have been totally debunked. The brain is plastic for life.
- Training your brain - Everything we do or think is a neural representation in the brain. Neurons talking to other neurons. We have an estimated 100 billion neurons (give or take a few billion) that create more than 100 trillion connections.
    - Such communications are neural networks.

- Synapses are gaps between neurons across which action potentials (electrochemical nerve impulses) travel.
- Action potentials travel down an axon which is punctuated by little gaps called the nodes of Ranvier.
- Just as with the electricity we use, if the conduit is not insulated then the action potential leaks out and the signal is not as powerful (does not travel as fast). The more insulated the axon the faster it travels.
- There are cells attached to axons called oligodendrocytes. Each time an action potential travels through an axon oligodendrocytes are activated to produce an insulating substance called myelin, which forms a covering known as the myelin sheath (Araque and Navarrete 1588; Wake, Lee, and Fields 1649-1651).

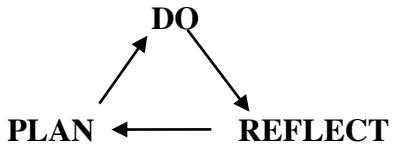


- The more insulated the axon the faster the action potential travels (i.e. faster cognition, finger movements, etc.). That is why thoughtful repetition over and over creates solid technical foundation and speed *in all domains*.
- Learning; slow accurate movements/thoughts create accurate neural representations ready for myelination.
- Eventually (it takes some time) enough myelin accumulates for a process called saltatory conduction to take place. This change between the processes has been called the "Lillie Transition" (Young, Castelfranco, and Hartline 533-546). In this process the action potential leaps across the axon at far greater speeds. Specifically it originates on both ends of the axon and meets in the middle instead of linear conduction from one end to the other.
  - Interestingly during the onset of the "Lillie Transition" action potential velocity decreases before the significant increase of saltatory conduction. This may explain plateaus in learning and why sometimes after working a lot on something we can seem to regress.

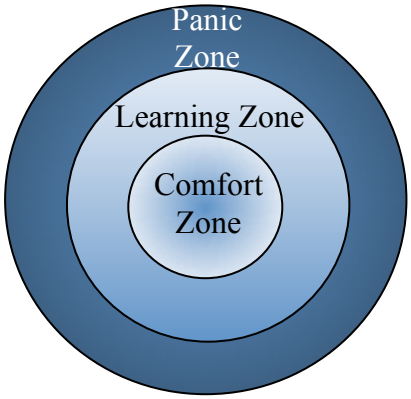
- We control our brains, how much we use them and how we use them.
- 10 years 10,000 hours to become world class in any complex domain, and that number is rising.
- The point is not to do 10 years 10,000, but to take the same steps as one would if one were to follow that process however many hours they may work to improve.
- And that process is. . .

Deliberate Practice

- Effortful activity generating constant feedback that guides the refinement of that activity over and over and over.
- The term was first coined in the 1993 paper, "The Role of Deliberate Practice in the Acquisition of Expert Performance," published in *Psychological Review* by the leading researcher in skill development K. Anders Ericsson and some of his colleagues and (Ericsson, Krampke, and Tesch-Romer).
    - He refined and updated this in, "The Influence of Experience and Deliberate Practice on the Development of Superior Expert Performance." (Ericsson 2006)



- Cognitive researchers have developed an inclusive model for the Plan-Do-Reflect model calling the three phases Forethought-Performance-Self Reflection, as well as addressing other environmental and psychological factors surrounding the paradigm of skill development (Zimmerman 707-715, 705-719).
- **One characteristic of deliberate practice** is that it is not inherently enjoyable. (Ericsson, Krampke, and Tesch-Romer 368).
    - It is work. Whereas physical work is taxing on the body, this type of intellectual work is taxing on the brain.
    - This state of difficulty is the 'sweet spot of learning'. I, half-jokingly, have called this the 'burn of learning' or the blearn – Feel the Blearn! Of course I later found it has a real name. Two UCLA researchers have described this condition as, "Desirable Difficulty," (Bjork and Bjork 58). Writing about the current state of education professor Bjork states, "optimizing instruction will require unintuitive innovations in how the conditions of instruction are structured (ibid 56)." Or to put it colloquially – learning is not what many people think that it is.
    - Vygotsky and the Zone of Proximal Development



- ". . .deliberate practice requires that one identify certain sharply defined elements of performance that need to be improved and then work intently on them. Examples are everywhere. . .Tiger Woods has been seen to drop golf balls into a sand trap and step on them, then practice shots from that near impossible lie. The great performers isolate remarkably specific aspects of what they do and focus on just those things until they are improved; then it's on to the next aspect." (Colvin 68)
- **How most kids do homework is not deliberate practice**. No wonder classes seem hard. Kids who do all the assignments *as assigned when assigned* in their homework do not need to study for tests to get A's (rich mental model). I have known plenty of honors students who do this and it has everything to do with how they prepare not 'giftedness'.
- **While there are no shortcuts in learning, there are longcuts** and most people take those.
- Might that knowledge benefit you, or any students you know? If they are convinced of their own efficacy then how smart they are is entirely up to them.
- **Recovery Periods.**
    - Engaging in deliberate practice is intellectually taxing (mental fatigue) and breaks need to be taken when serious confusion occurs.
    - Current research shows that world class experts cannot engage in more than 4-5 hours of deliberate practice daily (Ericsson 699). 90 continuous minutes of deliberate practice at a time seems to be the limit. Consider this if you want to introduce your students to this concept. Generally 45 minutes on and 15 minutes off works for high-level study. For beginners start with five minutes. This is far better than 15 minutes of unfocused work.
    - When true mental confusion occurs, however long that takes, a recovery period is necessary.
    - Leisure activity (Ericsson, Krampke, and Tesch-Romer 377).
    - Plan recovery periods.
- Recovery periods and sleep.
    - Studies show that high achievers take more naps (Ericsson, Krampke, and Tesch-Romer 376-377).
        - Memory is consolidated.
        - Recently it has been discovered that a 'sanitation system' called Metabolite Clearance that is not active during waking hours flushes out waste in the brain during sleep (Xie et al.).
    - **Focus is like a muscle.** Those new to this type of intense concentration will only be able to lift a little intellectual weight until exhaustion. Start with little bits at a time, it will grow, but do not push through genuine mental fatigue. Take a break and do something that takes little intellectual investment.
- Repetition – I can't stress enough the importance of massive amounts of <u>thoughtful</u> repetition (did I do it right? If not how do I fix it? If I don't know ask my teacher, etc.) in the pursuit of effortless performance (critical thinking within the domain). Performing is fun, learning is work; the more work you'll do the more fun you'll have. The good news is we've got about 12 years of schooling to do this a little bit at a time.

- Getting something 'right' is on only the *first* step. Then repetition can begin with an eye for anything that can be improved for each subsequent repetition. This process can take days, weeks, or months depending on the challenge.
- It is fine to make mistakes. It is not fine to not recognize and correct them. Pay attention.

- Interestingly there is a way to supercharge the brain's learning potential. . .

Varied Repetition

- The Power Law of Practice (Newell, Allen, and Rosenbloom)
  - What many of us call the '80/20 rule'. Most progress is made during the initial stages then progress slows, sometime to a halt (plateau) for a while and the last stages take a long time.
- "The Strategy Specific Nature of Improvement: The Power Law Applies by Strategy in Task," Delaney et al.
  - Varied repetition; the power law can be reset so that initial fast gains occur again by working on the same material in new ways.
  - Take Ben Franklin and writing. He learned to be a great man of letters through an ingeniously designed set of varied repetition.
  - "Several authors have shown similar effects of strategy changes on young children's arithmetic. For example, Siegler and Jenkins (1989) used concurrent verbal protocols and videos of young children who knew how to add using a simple counting-from-one rule. After 11 weeks of practice, almost all of the children had learned a more efficient rule that involved counting up from the larger addend rather than counting up from one. Children using this more sophisticated counting rule were faster at solving the problems because they had many fewer operations to perform to produce the answers. In summary, several studies in the domain of arithmetic problem solving indicate that strategy shifts occur along with improvements in solution times. ¶ In summary, several studies in the domain of arithmetic problem solving indicate that strategy shifts occur along with improvements in solution times."
  - This is present in all high efficiency/high level teaching and coaching.
- **Interleaving**
  - Spacing repetitions with periods of 'forgetting' in between increases learning.
- Don't just try these once or twice. Don't give up on new ideas too soon. Some of these will work better than others in certain situations. After you begin using them for a while that you will be able to identify the strategy needed for specific circumstances when necessary. In any case, doing any of this will work much better than doing none.
- Daniel Coyle, *The Little Book of Talent*.
  - Great ideas for the practical application of strategy changes applicable to any domain.
- Are you starting to see that. . .

Talent is Overrated

- Whatever that is.
- Consider how important, or not, this concept is to you.
- It is the subject of an excellent book that delves into the complex issues surrounding skill development. In *Talent is Overrated* Geoff Colvin writes, "If it turns out that we're all wrong about talent, and I will offer a lot more evidence that we are, that's a big problem. If we believe that people without a particular natural talent for some activity will never be very good at it, or at least will never be competitive with those who possess that talent, then we'll direct them away from that activity. We'll tell them they shouldn't even think about it. We'll steer our kids away from particular studies whether they're art, tennis, economics or Chinese because we think we've seen signs that they have no talent in those realms . . . most insidiously, in our own lives, we will try something new, and finding that it isn't easy for us conclude that we have no talent for it, and so we never pursue it. Thus, our views about talent, which are extremely deeply held, are extraordinarily important for the future of our lives, our children's lives, our companies and the people in them. Understanding the reality of talent is worth a great deal."
- The Role of Practice in the Development of Performing Musicians (Sloboda et al.)
    - A sample of 257 young people aged between eight and 18 who had undertaken individual instrumental tuition were interviewed in depth about their performing history from the start of playing. A subset of 94 of these individuals also kept a practice diary for a 42-week period. The data collected allowed estimates to be calculated of the amount of time devoted to various types of practice and other activities. The sample was selected in order to encompass a wide range of levels of musical achievement, from pupils at a highly selective specialist music school through to individuals who had abandoned instrumental study after less than a year of formal instruction. Data about formal examination successes confirmed the very wide range of achievement in the sample. It was discovered that there was a strong relationship between musical achievement and the amount of formal practice undertaken. Weaker relationships were discovered between achievement and amount of informal playing. There was no evidence that high achievers were able to gain a given level of examination success on less practice than low achievers. High achievers tended to be more consistent in their pattern of practice from week to week, and tended to concentrate technical practice in the mornings. These data lend strong support to the theory that formal effortful practice is a principal determinant of musical achievement.
- Mozart and Tiger Woods explained (Colvin 25-30).
    - Children of motivated master teachers.
    - Put in thousands of hours of guided practice starting at a very early age.
    - The Rochlitz letter
    - There is no magic here other than the unusually young age they started focused, guided, serious work with excellent coaching.
- My Twinkle story.
- **James Flynn** and his population IQ research. IQ, short of developmental disability, does not seem to matter, and you can build it.
- Are kids encouraged because they are talented or talented because they are encouraged?

- It can even be detrimental to believe in talent. (Dweck)
    - The Dangers of Believing That Talent Is Innate (Gopnik)
- So, if all of the previous turns out to be true then what stands in the way of anyone, really everyone being really great at whatever they choose. It turns out it is. . .

Self Control

• Also called executive function by neuroscientists and self-regulation by psychologists. Many people call
it willpower. This refers to the basic ability to choose "should" over "want".
• This is wired up in the pre-frontal cortex of the brain.

- The PFC is very underdeveloped in the young and will not finish developing until the age of 25 (ever wonder why your insurance goes down, or you can't rent a car until you are 25?).
- Self-control is learned just like instrumental skills – we engage in the behavior (create the neural network) and then reinforce it by repeating it over and over (myelination).
- Because this control of impulse is unpleasant for a young person, and indeed many people, many times they have to be taught, and sometimes structured into these behaviors. It takes a good deal of self-control on the part of parents and teachers to make children do things that appear to make the child uncomfortable in the interest of making them self-reliant adults. That is one of the greatest acts of love we can do for a child: not praising them effusively for doing nothing or being their friend.
- We have a limited amount of this resource and it while it is governed by the PFC it is fueled by glucose. (Baumeister and Tierney)
- These glucose fueled neural networks are *generic willpower*, that is to say that they can be used to make yourself do any number of things you may not feel like doing.

- **Self-esteem movement** of the 70's, 80's, 90's
    - Studies show self-esteem correlates with good grades (self-control) (ibid)
    - Educators and others believe that praising children for nothing (everyone gets a first place trophy!) will impart self-esteem thus facilitating better grades.
    - Researchers ran with it, with one in 1994 praising it. It made news, but what did not make news was the end of his report in which he said it was "disappointing" to see the lack of really solid evidence, "To date." (ibid)
    - Does anyone see the problem? What is the causal factor? Why believe that self-esteem leads to good grades *when it seems obvious that good grades lead to self-esteem,* and that is indeed what later research found and it seems this movement is coming to an end. But not after a generation was raised to believe they are superstars for doing nothing and expect to be treated that way. They have underdeveloped pre-frontal cortices and many of them are living with their parents as adults *with no intention of accomplishing anything else*. They may expect their parents to treat them a certain way, but that is not going to work with society at large.

    - Google, "You Can do Anything," a Saturday Night Live sketch for a hilarious view of this phenomenon (rated TV 14). After you laugh you may cry when you realize how accurate it really is.
- Creating motivation without failure.
    - This world does not exist, however there is much that can be done to reduce the negative and produce lasting positive habit patterns.

Habit Pattern Development

- Doing work properly, can be developed incrementally into a habit. (Duhig)
- Some research indicates it takes 30 days to build a solid habit, (Coyle) others longer, but these can be built through training (initial learning, then repetition).
- We are working on two things here: *amount* of work and *type* of work (as discussed earlier). Both can be trained simultaneously. Both are like muscles and can be developed as one would develop a muscle. Start with a little resistance and increase as strength increases.
    - Amount of work.
        - Fill out a time inventory (see attached time inventory sheet) and find 'sacred' work time.
        - We are working on getting started, quit without guilt. Identify the smallest details and begin building from there.
        - Start with 10 minutes 5 days a week. After two weeks it will begin to become a habit. That is to say that the act of getting started and going through the first 10 minutes is like tying your shoes. It may not be pleasant, but it is just something you do automatically without any significant discomfort.
        - Go to 15-20 for the next two weeks. The student can quit without guilt at 15. All I ask is that they *try* to push through for another minute. If not right away then eventually they will go past that without even noticing.
    - Type of practice. Focus; what it is and how to train it
        - What many people think is focus and work toward improvement is not. Thus significant improvement is rare. Getting work off of one's desk is much different than getting the work done right which is the essential concept of skill development.
        - Attention to every detail, the smaller the better – build up from there.
        - **Always endeavor to not give answers**, ask questions to let students find the answers. This is harder than just giving information and is a mark of master teaching. If you are new to doing this it will be a bit confusing and mentally uncomfortable. You are going through desirable difficulty (Feel the Blearn!), don't abandon it, embrace it.
        - Meta coaching.
        - 10x perfect game.
        - What if. . .
        - I'm going to ask you to play and listen to yourself and everyone else in your group. When you we finish this section be prepared to speak for 2-3 minutes about every aspect of everyone's performance. This brings the student to acute awareness paying attention to as many details as possible in order to fill the time (I usually start by becoming totally silent for 30 seconds. It seems like an

eternity and then I tell them I'll want them to fill at least four times that amount with their critique). I do not make them speak, but they always perform better on that attempt and learn what good focus is.

- Unfortunately many of us go about learning with a poor. . .

Mindset

- Researcher Carol Dweck and growth vs. fixed mindset.
  - Her three decades plus of research has addressed **why**, to put it colloquially, **most of us can't get out of our own way when it comes to learning**.
  - See attached handout
  - Praise the work, not the 'talent'. This is simply the truth and not a manufactured motivational strategy.
  - Perseverance/patience.
- **There are wrong answers** and we do a disservice to students when we don't allow them to face failure and solve these relatively small, relatively uncomfortable problems to build the skills of adult self reliance. Are they really that fragile?
  - Anthony Rizzzo
  - Americans and their words. . .
    - https://youtu.be/hSp8IyaKCs0?t=10
- We are called to be their mentors, not their friends.
- Don't believe the road signs that nature puts up along your quest for skill development.
  - Research shows that there is no fast track to improvement. Level of accomplishment always correlates with amount of practice.
  - Don't measure yourself against where you want to be, measure yourself against where you have been, and how you have improved over the course of months, at least.
    - That is not to say one should not hold in their minds, and observe in life, examples/visions of what one wants to strive toward. Having these models is especially important if high level skill acquisition is the goal.
  - Don't compare yourself to others by age. Compare by hours put in and, more specifically, the type of work done during those hours.
  - How progress is measured. Days vs. weeks or months. The long arc of performance development.
- **Skill acquisition is set up backward** to what most people perceive it should be. Many perceive that because something is hard at first and little progress is made with great effort that they do not have talent. In reality it is pushing through this initial phase and getting to a level of competence in which higher-level accomplishment can be trained *is itself* 'talent'. Many tend to think that being really good at something right away (which never happens, the research is overwhelming on this) reveals a 'talent' and then hard work to reach one's potential can begin. This is part of the misunderstanding of talent.
- **So how are we** supposed to get students to push through this and get to the point where their rich mental models make learning robust and fun? Why not try. . .

Real Accomplishment as Motivator

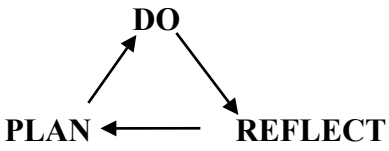
- We cannot get there without pushing through the initial learning (The Blearn, motivation, allocation of time, acquisition of instruction, etc.) just like your muscles would be sore and you would hurt for a while if you started working out, the brain will 'hurt' as one engages in meaningful skill acquisition. It is a myth that any given individual begins learning a skill *with no previous exposure or participation in that domain* significantly faster than anyone else.
- Development and Adaptation of Expertise: The Role of Self-Regulatory Processes and Beliefs by Barry J. Zimmerman.
    - Using several domains this research showed that genuinely getting better (good) at something through proper training created a genuine interest in participating in *and improving* in a given domain. "Because successful learners view strategic processes as effective means to an end, they are motivated more by the attraction of positive outcomes of these processes than by the fear of adverse outcomes (Pintrich 2000),"
    - This is the source of real self-esteem and self-efficacy.
    - Passion can be developed and nurtured. Could all passion for life pursuits come from here?
- **Flow** (Csikszentmihalyi – Pronounced: "Csikszentmihalyi")
    - When high ability meets a higher challenge we lose ourselves in the challenge and time melts off the clock. This is the most efficient way to coach and design lessons.
    - He makes a distinction between enjoyment (when the brain is stimulated and we are in flow) and pleasure (lying on the beach, watching TV, etc.)
    - The good news is that it appears the brain is designed to crave high level problem solving/cognition, after all that is how humanity has advanced over the course of time, but the price of this productive state of enjoyment is persevering through the initial unpleasant stages.

Teaching Creativity

- Creativity, as most experience it, is a performance of intelligence.
    - "Creativity is intelligence having fun." - Albert Einstein
    - Big C, little C and mini C creativity (Colvin 159)
- In this brand new age of globalization there will always be someone somewhere who is willing to manufacture something more cheaply than we can in America and maintain the expected quality of life. Former Federal Reserve Chairman Alan Greenspan wrote of this;
    - "Manufacturing jobs can no longer be highly paid, since it is consumers who at the end of the day pay the wages of factory workers. And they have balked. They prefer Wal-Mart prices. Those prices, reflecting Chinese low wages, are inconsistent with a funding of high-wage traditional U.S. factories. Forcing U.S. consumers to pay above-market prices to support factory salaries eventually would run into severe resistance. But by then, the American standard of living would have fallen." (Greenspan 395-396)

- "In a world of forces that push toward the commoditization of everything, creating something new and different is the only way to survive. A product unlike any other can't be commoditized." (Colvin 146)
    - ". . .too many of our students languish at too low a level of skill upon graduation, adding to the supply of labor in the face of an apparently declining demand." (Greenspan 399-400)
- Take Apple – created here, made there.
- There has been a push to teach creativity in schools for some time. Sometimes with disastrous results.
    - In 1989 the National Council of Teachers of Mathematics, ". . . report recommended a curriculum that dropped emphasis on basic math skills (multiplication, division, square roots, and so on) and pressed students to seek more free-flowing solutions and to study a range of special math topics. I always wondered how you can learn math unless you have a thorough grounding in the basics and concentrate on a very few subjects at a time. Asking children to use their imagination before they know what they are imagining about seemed vacuous to me. It was." (Greenspan 406). They have since reversed that position.
    - ". . .cognitive load theory suggests that the free exploration of a highly complex environment may generate a heavy working memory load that is detrimental to learning. This suggestion is particularly important in the case of novice learners, who lack proper schemas to integrate the new information with their prior knowledge." (Kirschner, Sweller, and Clark 80)
- And this about where we currently stand when it comes to teaching creativity in most subjects. How, then, should we do it?
- The first thing we should understand is exactly what Greenspan was addressing – How can you create in a domain without requisite knowledge?
    - ". . .the epistemology of a discipline should not be confused with a pedagogy for teaching or learning it. The practice of a profession is not the same as learning to practice the profession." (ibid 83)
    - Do what they did, not what they do.
- Creativity at the atomic level. The creative process is present in the steps involved in deliberate practice.
    - **Plan** - Even the most rudimentary solution, even a wrong one that the student should be guided to understand was wrong in the reflect stage, is problem solving which is separate from problem discovery. This is the exercise of rudimentary creativity. – generating an answer that was not there before. The continued refinement of those answers over time is the refinement of the creative process.
    - **Reflect** – This is the act of critical thinking. This can be done with the young, though they need to be scaffolded in the problem discovery process. In a 1987 study on that issue researchers found, "These results suggest that problem discovery is associated with creative performance in adolescents. . .This result is consistent with Arlin's (1875) position that problem finding is a developed skill and only becomes distinct from problem solving skill during adolescence." (Runco and Okuda 217) Can you see the educational progression from the very basics to higher-level creativity?

    - High-level creative thought has already worked through basic solutions thousands of hours and repetitions ago. What is left are novel solutions born of a rich mental model.
- This follows the recommendations of The President's Committee on the Arts and the humanities.
    - ". . .the approaches used in teaching the arts are very compatible with the development of balance among the three types of abilities associated with creativity as described in a well-known theory of creativity development:
        - **synthetic** ability or generating new and novel ideas;
        - **analytic** ability or critical thinking which involves choosing which ideas to pursue; and
        - **practical** ability or translating ideas into action (Sternberg & Williams, 1996)."(38-39)
    - Does this sound familiar!?



- Manipulate basic information using strategy changes to apply deliberate practice at the earliest stages and reinforce to students, and everyone else for that matter, that they are learning the very beginning stages of high level creative thought.

Now, what in the world is a recovering high school music teacher doing teaching you this?

The Surprising and Unique Usefulness of Teaching The Arts

- **There are no B+'s in arts education**, yet some celebrate them elsewhere. What is going on?
- It is interesting (to note) that if we got our dry cleaning back with 89% of the stains out, or our Happy Meal missing 11% of what we paid for we would find that unacceptable, yet we can consider that a successful level of competence in other areas. The goal of all learning is competent performance, and music shows us how to teach it. (Goodhart 2016)
    - Why Music Education Matters in Academics: It May Not Be What You Think. (Goodhart 2014)
- Imagine a 90-minute play or music performance in which 11% (10 full minutes) were unintended (mistakes). That is not 10 mistakes, but 10 full minutes of them. Imagine visual art with 11 percent that was not at all what the artist intended. (I'm looking at you Jackson Pollock!)
    - Why A is not Enough https://youtu.be/KpyzGO2aQzE?t=20 -2:30
- Arts teachers must, as a normal part of their jobs to be considered 'good,' get all of their performing students to about 98% or better. The really good ones get very close to 100%. I taught music successfully for 13 years at the high school level. It is a common myth that arts teachers at the pre-college level seek out 'talented' students, or identify them in their

classes, and then develop them. What we do is take anyone and everyone and know that if they will follow our directions (the learning process in its purest form) they will get good.

- **Teaching the arts teaches learning.**
    - The goal of all learning is performance
        - Are we starting to see the bigger picture here?
- Because of this arts teachers, as a natural course of doing their jobs over the last few centuries, have had to learn the essence of the learning process and immerse students within it, literally rewiring the brain physically and functionally. This process has been around as long as humanity, and is responsible for all great human achievement from the Renaissance (the apprenticeship model is excellent for developing mastery) to Beethoven's symphonies and Jimi Hendrix' guitar work (Goodhart 2016)
- Newer research has begun to enlighten us as to what is going on neurobiologically in arts instruction that serves this.
- "Improved Effectiveness of Performance Monitoring in Amateur Instrumental Musicians."
    - ". . .for present purposes, higher levels of musical practice were also associated with a better engagement of cognitive control processes, as indicated by more efficient error and conflict detection. . .and reduced post-error interference and post-conflict processing adjustments." (Jentzsch, et al.)
        - To put it another way it trains the brain to search for areas of error, is able to maintain focus instead of giving in to frustration, and then make adjustments based on finding those errors over and over as one works. I believe we teachers have a word for that – learning. That is how learning works for any subject, any skill, anything. The more you do of it the better, smarter, faster you get.
- It turns out that high efficiency learning does not work the way most people think it does (is it any wonder we've been trying to 'fix' our school system for over half a century?)
- So then what is it, what is the difference? Process over content. How do we understand the essence of what we do to teach students to apply this everywhere, and even teach our academic colleagues how to get results more like ours!

Whether you think you can, or you think you can't – you're right.

-attributed to Henry Ford

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Recommended Reading

Start with the first three, they are the jumping off point for everything you need to know and research.

Talent is Overrated: What *Really* Separates World-Class Performers from Everybody Else
Geoff Colvin

For my money the single best reference on the nuanced overarching idea of talent, how we wrongly perceive it, and how these implications inform teaching and learning. Unlike Outliers Colvin describes the things that you need to do to be successful. He also points to research you can review on your own. It is scholarly, but also it is an entertaining read.

Willpower: Rediscovering the Greatest Human Strength
Baumeister and Tierny

These researchers have done some amazing work on what happens in the brain with regard to self control and how it is been trained. They also cite other relevant research and weave together a compelling take on how discipline is learned. Another scholarly entertaining read. This, TIO, and Mindset are the fundamental must-reads of this list.

Mindset: The New Psychology of Success
Carol Dweck

Professor Dweck has spent over three decades researching the *psychology* of learning. Since learning is different than what most people think it is things like failure and mistakes seem to indicate a lack of ability to them. In an attempt to appear competent they cover this by not participating in learning. It is, of course, more complex than that and her work is fascinating. You will recognize it all around you and likely, as did I, in yourself to some extent.

The Little Book of Talent
Daniel Coyle

An owner's manual containing specific things great coaches and teachers use to maximize skill development. I am amazed that an investigative journalist could figure this out so well. I thought one would have to do thousands of hours of teaching. This is an invaluable resource.

The Talent Code: Greatness isn't born. It's grown. Here's how.
Daniel Coyle

Mr. Coyle elucidates an exciting theory at the time (2009), and proposes that all human improvement can be traced to a single biological process. This process is myelination. Myelin is an insulating sheath around axons in the brain. The more insulation the faster the nerve impulse travels. Thus faster cognition, motor skills, etc.

Since 2009 important research has been published showing evidence that the underpinning process Mr. Coyle writes about is indeed accurate. As you read it keep in mind that starting in 2011 it has been shown scientifically that sending an impulse through an axon does cause an oligodendrocyte to produce myelin.

The Genius in All of Us: New Insights into Genetics, Talent and IQ
David Shenk

Another take on the same theme. He identifies a new paradigm for nature vs. nurture (nature *times* nurture) and explains how much of what we think about genetics is not correct. This is partly an introduction to epigenetics which is a very active field now.

The Power of Habit: Why We do What We do in Life and Business
Charles Duhigg

How hard is self control really? It can be developed into a habit. This is a well-researched, practical and interesting look into how our brains ingrain and act on habits and what we can do about them for ourselves and in teaching others.

Outliers: The Story of Success
Malcom Gladwell

Gladwell uses good storytelling to show how the environment we create influences success and that it is not innately limited. It is probably the most interesting read, but the least scientific, and he does not explain *how* the process works. I describe it as *Entertainment Tonight* to Colvin's *60 Minutes*. In any case it is a worthwhile read. The information on Canadian hockey players and how that speaks to the talent myth is worth the price alone

Good Business Leadership: Flow, and the Making of Meaning.
Mihaly Csikszentmihalyi

Csikszentmihalyi (pronounced 'Csikszentmihalyi') first described the concept of flow in the late 1990's. This is the state experienced when time melts away as you are working on a task. You've worked hard, done a lot, but it feels like hours have passed in moments. In Good Business, one of his several books on flow, he describes the concept on its own and relates to business structures. In any case the application of flow in any group setting has benefit and this book is quite illuminating. Don't dismiss it upon first read, it took a while for this to sink in, but when it did it had a profound effect.

The Willpower Instinct: How Self-Control Works, Why It Matters, and What You Can Do To Get More of It
Kelly McGonigal

A great companion to the Baumeister/Tierny book. Suggests exercises you can try for a week at a time and looks at some of the issues from a different angle.

Addendum:

The Cambridge Handbook of Expertise and Expert Performance
Edited by K. Anders Ericsson et a.
Ericsson has established himself and his team as the leading research authority on skill acquisition and expertise over the last 30 years. This is not a book per se but a collection of peer reviewed studies on all aspects of performance development including how it is done in specific fields, how motivation works, the specific process of skill acquisition (deliberate practice) and more. It is not a light read, very clinical, and at 900+ pages I myself have not read it all. I have read much of it and its organization makes it easy to pick which studies one wishes to read (I have found no need as of yet to read how one becomes an expert in software design, for instance).

The Role of Deliberate Practice in the Acquisition of Expert Performance. 1993
Anders Ericsson et al.
The seminal paper that first described the path to world class performance. It is available online. He updated it in the Cambridge Handbook as, "The Influence of Experience and Deliberate Practice on the Development of Superior Expert Performance," but what he wrote in 1993 is still accurate. If you like the 1993 paper then spend the $60 on the book.

The Strategy Specific Nature of Improvement: The Power Law Applies by Strategy in Task
Delaney et al.
The paper that first studied and identified the efficacy of strategy changes.