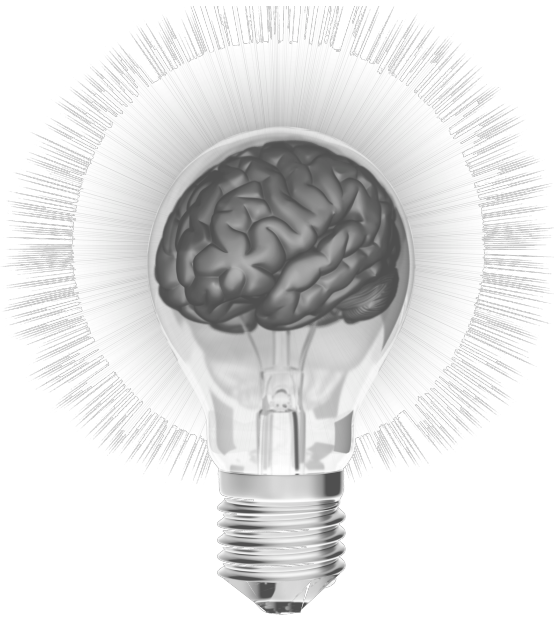
The Ecosystem of Learning... …Anything

Lecture/Seminar Notes



Gregg Goodhart

The Learning Coach

How successful we are at anything we wish to do, from sports to arts to academics to life, will be determined by how well we learn to do that thing. Learning is indeed the most powerful and important piece to achieving whatever it is we wish to accomplish even if that is just improving a little bit.

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

-Bjork and Bjork (2011, p. 5

What Are Your Goals?

- To learn how learning really works, to learn well.
- There is a lot here, but believe it or not this is just the tip of the iceberg. These are just jumping off points for more investigation. So, as much as there is, there is much more to understand and that will grow the more we use it. That is the learning/teaching journey.
- These things should be taught in school from a very young age, but are not. Schools of education (that prepare teachers) are siloed from schools of cognitive science. Our teachers are not taught to understand and use these things in a meaningful way. We learn almost none of this in school, and in some cases, we learn the opposite what works best.
- ***My job is to make the 'Ecosystem of Learning' understandable and immediately useful in learning and teaching for immediate and long term, continuous, success.***

Learning Changes the Brain with Surgical Precision

- Learning is tantamount to brain surgery. While it is quicker with a scalpel, we use cognition to change our brains physically and/or functionally (neuroplasticity), and we do it in very specific ways depending upon the subject.
- We know how to build our muscles, and are not surprised when they change with exercise, but since we can't see the changes that happen in the brain, the way learning really works is a locked box to most of us.
- 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.
- 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.. . . 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. (Hardiman, Rinne, Gregory, & Yarmolinskaya, 2010. pp. 145, 157)

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

THE CAMBRIDGE HANDBOOK OF EXPERTISE AND EXPERT PERFORMANCE

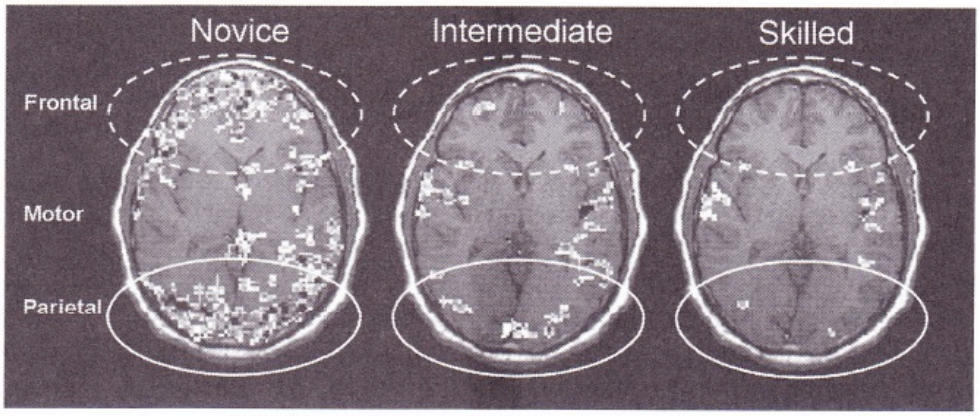


Figure 37.1. Activation of the brain, as a function of practice, in three periods of learning a motor tracking task. This is a maximum projection image, with white areas showing the activation of any cortical area either above or below the illustrated brain slice. The image is an axial (aerial) view 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.

(Hill & Schneider, 2006, p. 656)

- Process Efficiency Change (Hill & Schneider, 2006) – less is more
    - During this process the brain is working through confusion to find the perfect efficiency point for that task. This occurrence has been called a process efficiency change.
    - At first the brain is very active. As the task is learned, more and more regions drop out as the brain finds the perfect efficiency point for the desired ability. Now the skill can be reliably executed. This process can be difficult and frustrating as the brain tries to figure out how to best represent the new skill.

Neuroplasticity/Learning Happens in Your Brain

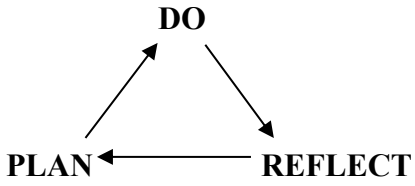
Learning changes Brains with surgical precision, literarily

- 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, 2007)
    - Violinists left hand representations, London cab drivers Hippocampi. On and on.
- This is the scientifically proven idea of neuroplasticity.
    - 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.

- We control our brains, the neural networks we create and how we use them.
- The more problems we fix within a domain the better we get at fixing them in that domain (learning how to learn), and the quicker and quicker we get better at whatever it is we are trying to do.
    - And that process is. . .

Deliberate Practice

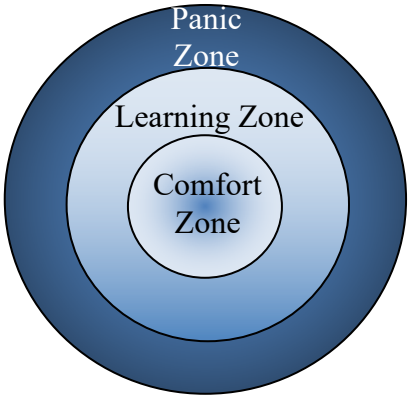
- At least 10 years and 10,000 hours to become world class in any complex domain, and that number is rising.
    - The point is not to do tens of thousands of hours of work, but that we know the methods that worked to get those people from beginner to master.
    - Anyone take the same steps however many hours they may work to improve.
    - There is always a way to address whatever it is that is keeping us from improving. Getting better means solving the problem in front of us at any given time. Becoming great is just solving the problem in front of us hundreds of thousands of times. Becoming competent (good grades) takes a lot less than that, and just improving from our current state even less. It is our choice how skilled we would like to become once we understand the science of leanring,
- Effortful activity generating constant feedback that guides the refinement of that activity over and over and over.
- The term first appeared 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. (Ericsson, Krampke, & Tesch-Romer, 1993)
    - 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, 2007)
- "One characteristic of deliberate practice is that it is not inherently enjoyable." (Ericsson, Krampke, & Tesch-Romer, 1993, p. 368)
    - It is work. Whereas physical work is taxing on the body, this type of intellectual work is taxing on the brain, though it quickly becomes engrossing and enjoyable.
        - Of course there will be challenges and difficulties along the way. No significant learning occurs without it. Dealing with this aspect is

something that can be trained a little at a time while creating enthusiasm for more learning.

- Vygotsky and a version of 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, 2010, p. 68)

- **How most students do homework is not deliberate practice**. No wonder classes seem hard. Students who know how to apply deliberate practice in their work need to do less of it and do not need to cram for tests to get superior grades (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.
- Recovery Periods and sleep
  - Learners should start with small bits of time learning to apply this type of focus.
  - When true mental confusion occurs, however long that takes, a recovery period is necessary.
  - Leisure activity. (Ericsson, Krampke, & Tesch-Romer, 1993)
  - Plan recovery periods.
  - Research shows that high achievers take more naps (Ericsson, Krampke, & Tesch-Romer, 1993).
    - Memory is consolidated.
    - A 'sanitation system' called Metabolite Clearance that is not active during waking hours flushes out waste in the brain during sleep (Xie, et al., 2013).

    - 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.
    - It is fine to make Recognize and correct them (mindset) instead of feeling negative. The whole outlook changes when we know we have solutions to learning.. Pay attention.
        - **Training metacognition as a precursor to deliberate practice.**
- Interestingly there is a way to supercharge the brain's learning potential. . .

<u>Distributed Practice/Contextual Interference/Retrieval Practice/Retrieval Structures</u>

- The Power Law of Practice (Newell & Rosenbloom, 1981)
    - 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, Reder, Staszewski, & Ritter, 1998).

Contextual interference

- Varied repetition; the power law can be reset so that initial fast gains occur again by working on the same material in new ways.
    - This produces difficulty (getting worse to get better/rapid improvement!)
    - Two UCLA researchers have described this condition as, "Desirable difficulty." (Bjork & Bjork, 2011, p. 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." (p. 56). Or to put it colloquially – learning is not what many people think that it is.

Contextual performance, not to be confused with contextual interference, is different than studying.

- Learning – isolating and working on small areas over and over, applying things like contextual interference to increase facility. This uses working memory, which holds about 7-9 pieces of information at any given time. Our corrections and improvements are informed by our recent memory of what we just did.
- Contextual performance – Such as a test or having to use the information in real time to solve problems/perform in a game (critical thinking) "One and done," type situations.
- This requires accessing information from long-term memory which can be practiced for greatly increased speed and accuracy. This can be where testing and performance anxiety originate. What seemed easy to remember in the moment, while we held it in memory during studying, seems 'forgotten' when we have poor access to long-term memory in the moment of performance/testing.

The following learning interventions are related and sometimes intertwined; there are elements of some within others. The owner's manual for distributed and retrieval practice strategies like this is the book, *Make it Stick*, (Brown, McDaniel, Roediger, 2014) and it can be layered on to any teaching/learning we are already doing. I cannot recommend this book highly enough, though it is a bit advanced.

Two other researchers who have done a significant amount of work in this area are Robert and Elizabeth Bjork at UCLA. Their, "Learning and Forgetting Lab," has an online presence with resources for understanding these concepts, and their important and fascinating research.

Random Practice, Retrieval Practice and Varied Repetition

- Creating certain difficulties in the learning process increases retention and retrieval.
    - Word problems in math.
    - Low stakes quizzes/tests (i.e. not for a grade) as a study method. After periods of studying something, giving random tests (by another or to oneself as part of studying) to take advantage of the testing effect. Even giving a wrong answer will make the retrieval of the right answer in the future more likely. It sounds crazy - in the mistake is actual learning! So, no need to worry about getting the answer wrong, just try. The science is clear on this and I've experienced it over and over with myself and my students.

> Taking a memory test not only assesses what one knows, but also enhances later retention, a phenomenon known as the testing effect. We studied this effect with educationally relevant materials and investigated whether testing facilitates learning only because tests offer an opportunity to restudy material. . . . prior testing produced substantially greater retention than studying, even though repeated studying increased students' confidence in their ability to remember the material. Testing is a powerful means of improving learning, not just assessing it. (Roediger & Karpicke, 2006, p. 249)

Retrieval Structures

- A good memory can be trained in any healthy person.
    - Dual coding
    - Mnemonic devices
    - Chunking

Elaboration

- Taking the plan-do-reflect model of deliberate practice and discussing and refining how what you are learning might relate to other areas/situations/uses/contexts No idea is unreasonable. Refine it from there.

Spacing

- The spacing effect is "a case study in the failure to apply the results of psychological research." And this refers to research that has been available since the late 19th century. "The spacing effect was known as early as 1885 when Ebbinghaus published the results of his seminal experimental work on memory" (Dempster, 1988, p. 627).
    - What else have we been missing?
- Putting periods of forgetting in between retrieval to strengthen availability in contextual performance.

    - Plickers
    - Leitner system
        - Anki flashcard app
    - Low stakes quizzing/testing
- This technique is so unusual and frustrating that even when students experience the benefits many will choose to go back to older less efficient ways of learning.
    - ***This is why coaching is important.***

Interleaving

- Similar to spacing, but different. Spacing can occur over hours, days, weeks. Interleaving occurs within single sessions by regularly switching what we are working on.
- Conventional wisdom holds that working on something doggedly for long periods of time is the best way to learn/improve. One reason for this is the presence in working memory of whatever information is needed to improve the next phase. The goal, however, is to get this information into long-term memory so that it is permanently present then learn to retrieve it 'on the fly'.
- Research shows that moving on to a new task *before* something feels comfortable achieves this. For instance, don't work on one concept for 30 minutes then another for twenty. Do one for three 10 minutes sections with 10 minutes of the other in between each.
    - The reconstitution or relearning of what we learned during the last section has powerful lasting effects for learning.

The idea with spacing and interleaving is that long-term strength of learning is increased if short-term learning is made to be more confusing/challenging *in specific ways. It is important to note that everything that makes learning more confusing is not beneficial, and things that might not be beneficial at one stage of learning may be beneficial at others. Navigating this is the high art of teaching.*

- If used correctly learners will actually appear to do worse in their learning at first, and this applies to many of these learning interventions. This is part of the process and what one researcher identifies as one of the most significant fallacies in learning. Professor Robert Bjork describes this in a podcast.

> . . .to the degree you interpret current performance as a valid measure of learning you will do all sorts of things wrong as a teacher, as a student managing your own studying, in terms of judgments you make about whether you can stop studying, to keep studying, what you should study. All of those things are kind of at risk so to speak if you interpret your current performance as learning. (Kime, 2018, 28:58)

- Are you starting to see that. . .

Talent is Overrated

- If talent exists, and it may, research shows that it does not seem to matter.
- 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* Colvin (2010) 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.
> (p. 20)

- Mozart and Tiger Woods explained (Colvin, 2010).
    - Children of motivated master teachers.
    - Put in thousands of hours of guided practice with a master 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.
- The misunderstanding of talent can happen right under our noses, and not be noticed. Yo-Yo Ma's ma. Despite enormous environmental prompts and advantages she has no idea from where he got his capacity to learn music. (Shenk, 2010)
- Are kids encouraged because they are talented or talented because they are encouraged?
- At least10 years and over 10,000 hours to approach world class excellence 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. The code has been cracked, now use it to make however much work we do pay greater dividends in intelligence and skill development.
- There is always a way to improve whatever it is that is keeping us from improving. Becoming great is just solving the problem in front of us thousands of times, and becoming better is just solving the one in front of us at any given time.
- 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.
    - Developing this control can seem unpleasant, but the science shows us ways to gradually learn it painlessly while creating enthusiasm to fuel even greater levels of dedication.
    - The PFC is very underdeveloped in the young and will not finish developing until the age of 25 (ever wonder why insurance goes down, or we can't rent a car until we are 25?).
    - Self-control is learned just like other skills – we engage in the behavior (create the neural network) and then reinforce it by repeating it in different situations (multivariate experience).
    - We have a limited amount of this resource, but with work it can be increased as *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. (Baumeister & Tierney, 2011)

Habit Pattern Development

- Habit pattern development. Doing work properly, can be developed incrementally into a habit. (Duhigg, 2012; Baumeister & Tierney, 2011)
- We are working on two things here: *amount* of work and *type* of work (as discussed earlier). Both can be trained simultaneously. Developing them is similar to developing muscles. Start with a little resistance and increase as strength increases.
    - Amount of work:
        - Develop orienting selective attention – getting started - first (Stevens & Bavelier, 2012) and the amount of work will follow from there if done correctly.
    - Type of work. Focus; what it is and how to train it:
        - Start with a little. Choose a task and pay attention to detail, the smaller the better. Follow the Plan-Do-Reflect-Plan model. This will become uncomfortable after a few minutes. Take a break. As our skill grows it will become easier and increase over time.
- Unfortunately many of us go about learning with an inefficient. . .

Mindset

- Researcher Carol Dweck. (2006)
    - 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.
- It is important to understand that we sometimes evaluate and decide to use information based on unreasonable emotional evaluations. We may know we are doing it, but do it anyway. That is a choice, and it is not very hard teach students to assess their work and goals with a growth mindset.

- This is the teaching of 'buy-in'. It is hard to get full focus if the student does not truly believe that what they are doing will pay dividends, and not only will it pay dividends every time, but learning will become more and more fun as one gets better and more skilled. It is OK to feel bad, now on to the fixing it in a way we know will work – growth mindset.
- Consider the following

Much of following, through the 'Barry's dad' section, was taken from a Revisionist History podcast episode. (Gladwell, 2016) Some of the stats were corrected using basketballreference.com.

- Wilt Chamberlain, Hall of Fame NBA player, still holds the single game scoring record with a 100 point game at the end of the 61-62 season. 50% free throw shooter before this year, his career best at 61.3% (16 year career average 51% with many years in the 40's). 28 out of 32 at the line, 87.5% in the 100 point game.
    - Teammate Rick Barry (Career FT 89.3% [94.7% in 74-75]. Over 90% 8 out of 10 seasons with one other being at 89.9%) Wilt modeled his free throws on Rick, and shot a career-best 61% from the line in 1961–62 ups from 50% the previous year. And that was just the beginning.
    - Rick Barry would miss 9-10 FT per season, LeBron typically misses about 150. **How did he do it?**
    - Barry explains that his technique improves shooting from the line for big men. Softer hands on free throws, more 'bad' shots go it. If you are offline it is more forgiving.
    - What did Chamberlain do? Shot underhanded, 'granny style', between his legs.
    - So, he had a problem, tried a solution and it worked so well that he set an all time record, then stopped doing it. Barry says – he could have been way, way better.
    - He had every incentive to continue. He improved from 50% to 61% in just the first season he started working with the technique, and the 100-point game was at the end (of course!).
    - He never shot free throws that way again. According to Wilt in his autobiography.

> I felt silly like a sissy shooting underhanded. <u>I know I was wrong</u> (emphasis added), I know some of the best foul shooters in history shot that way. Even now the best one in the NBA, Rick Barry, shoots underhanded. I just couldn't do it."

    - Barry approached Shaquille O'Neal, a career 52% free throw shooter, and offered to teach him how to improve. According to Barry, O'Neal said, "I'd rather shoot zero than shoot underhanded." What if Shaq shot 80%. Think of that career. And why did it not happen?

    - Barry worked with a modern NBA guy who got it down, then never had the nerve to use it. Barry will not give his name so as not to embarrass him!
    - What is there to be embarrassed about? Being great?
- Barry's dad told him in high school to shoot underhanded. He was already about 70%. He did not want to do it – Dad their going to make fun of me. "Son, they can't make fun of you if you're making them." He did it and in the first game on the road a guy in the stands yells out, "Hey Barry you're a big sissy shooting like that." They guy next to him says, "What are you making fun of him for he doesn't miss."
    - There is always a solution. Do we always pursue it?
- What if we are just a small tweak away from upping your skills like that?
    - We are.
- Growth vs. fixed mindset
- How do most of us deal with failure/mistakes during the learning process?
    - Why are mistakes a problem, and why should they make us upset? They are instead opportunities to learn what not to do, just pieces of information for the reflect and plan phases of deliberate practice that move us closer to better and better performance.
    - Once, after his college team lost the last game of the season Michael Jordan went and practiced his shots for hours.
    - Praise the work, not the 'talent'. This is simply the truth and not a manufactured motivational strategy.
- 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

- It is a myth that any given individual begins learning a skill significantly faster than anyone else *with no previous exposure or participation in that domain*.
- Development and Adaptation of Expertise: The Role of Self-Regulatory Processes and Beliefs by Barry J. Zimmerman (2006)
    - 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)," (p. 709)
    - 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
(deliberate practice is a flow-producing 'machine')

- The good news is that it appears the brain is designed to crave high level problem solving/cognition.
- This is the work of Mihalyi Csikszentmihalyi (2003) who has devoted his career to explaining that state of losing ourselves in a challenge, time melting off the clock, and much being accomplished. This is what some people refer to as the 'zone'.
- It is a real psychological phenomenon, and it appears that this is the highest state of efficiency at which we can function.
- Deliberate practice, done properly at any level of learning, is a flow producing machine.
- The mental state of operation in which a person performing an activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of the activity. In essence, flow is characterized by complete absorption in what one does, and a resulting loss in one's sense of space and time.
- If the task is too easy we will become bored If the task is too difficult we will become This is the state we all strive for, but we do not know that as beginners.

Teaching Creativity at the Atomic Level

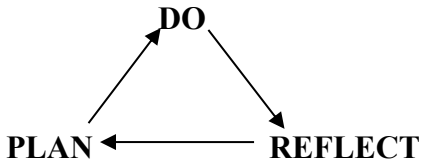
- Creativity, as most experience it, is a performance of intelligence.
    - "Creativity is intelligence having fun." - Albert Einstein
    - Big C, little C and mini C creativity (Colvin, 2010)
- There has been a push to teach creativity in schools for some time. Sometimes with disastrous results.

> 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, 2007, p. 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." (Kirshner, Sweller, & Clark 2006, p. 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." (Kirshner, et al., 83)
    - Do what they did, not what they do.
- The President's Committee on the Arts and the Humanities. (2011)
    - ". . .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)."(pp. 38-39)
    - Does this sound familiar?



- Manipulate basic information using the described learning strategies 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.
- Teaching 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 & Okuda, 1988, 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.

The Surprising and Unique Usefulness of Teaching The Arts

- There are no B+'s in arts education.
  - 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.
  - *Why A is Not Enough* https://youtu.be/KpyzGO2aQzE?t=20 (Devonshire, 2011, 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. 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 they do is take anyone and everyone and know that if they will follow their teaching (the learning process in its purest form) they will get good.
- Teaching the arts teaches learning.
  - The goal of all learning is performance (to perform the skill as needed in real time).
- 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.
- 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.* (Jentzsch & Kansal, 2014)
    - ". . .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." (p. 21)
    - 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 systems for over half a century?)
- So then what is it, what is the difference? Process over content

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

-attributed to Henry Ford