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Foundation Course: Learning how to Learn

Updated December 2022

What this page is about

Lots of people studying courses like ours have not been in a structured learning environment for a long time. Quite a few of you have said you struggled at school because your learning style did not fit. Probably even more of you have spent quite a bit of study time haphazardly waiting for enthusiasm to come along, and now you are at last learning something you want. But some of the old habits can still lie in wait, making it hard to keep up when material gets a bit more difficult, or hard to remember things you felt at the time you could never forget. So here are some notes, not only tried and tested but thoroughly researched, that may help you get more out of your study time with us.

The Learning How to Learn course

This Coursera 4-week course, https://www.coursera.org/learn/learning-how-to-learn offers a lot of skills and science. One of its founders, Barbara Oakley, was hopeless at Maths when she was at school, and became a translator. And then she needed to understand engineering terms better for her translation work and needed to understand Maths to understand the engineering concepts - and found she could do it very well! So this a course by, and for, people who have experienced frustration in learning things and would like to overcome it, and there is also a book by Barbara Oakley and Terrence Sejnowski (neurobiologist and co-founder of the course).

The notes here (taken from the 2015 version of the course) capture a few of the main ideas and techniques. If you are interested in taking the Professional Course, and have the feeling that better learning skills would come in handy (fairly likely, as it is a demanding course), these notes are likely to be particularly useful and contain plenty to practice and follow up, and you might well be interested in taking the Learning How to Learn course before you start, or in the long summer break.

1. Work, rest and play

Focused and diffuse modes of learning

These are two modes of learning that can be compared with the movement of the ball in a pinball machine, focused, where it is very fast and direct, and diffuse, where it bounces all over the place.

Focused mode

The type of intense concentration you need to work through a problem, step-by-step favours the focused mode, where thoughts are held in a familiar pathway, modelled by an area where the bumpers are closed together so that the ball (impulse) cannot escape easily.

Diffuse mode.

The diffuse mode is the type of thinking you need to do when you are trying to understand something new, where the pathway that needs to be used is in an unfamiliiar area and to reach it there need to be fewer barriers there, though the ball (impulse) will not be held there because there are also fewer barriers to restrain it. Using a different analogy, the diffuse mode could be thought of as a flashlight set so that it casts its light very broadly, but not very strongly in any one area. (As opposed to the focused mode, which would have its light cast very strongly in a single area, but very weakly everywhere else.)

Combining the modes and timing them

- To learn new material, especially when it is abstract, you need to combine the two approaches
  - learn in short (25 minute) focused sessions regularly - with no distractions, (the Pomodoro technique - set a 20-25 minute timer and stop when it rings).
  - interspersed with spells of relaxation and reward
2. The two modes function alternately, not simultaneously

The Pomodoro Technique

There are lots of online resources that you can use to put this technique into practice: Here are two: Pomodoro Technique link 1 and Pomodoro Technique link 2.

Memory:

Working memory holds what is being processed consciously right now. It is based in the prefrontal cortex,where there are also connections to the many other areas of your brain where long term memories are stored. It used to be thought that seven pieces of information could be stored there at a time, but now it seems that four is a better estimate. It seems more because of the way information is chunked.

- Working memory is evanescent and subject to being flooded by new information before connections can be made, which explains techniques such as closing one's eyes or ears and repetition.
- Long-term memory is permanent and can hold billions of items, including the concepts and techniques needed to understand new material that is focused on by working memory. However, the content of long term memory is scattered across the brain according to its type. Storing new material means holding information in working memory long enough and repeatedly. It is much more effective to space this repetition out over several days than to do it in a single intensive session.
- Interaction between consciousness and long-term memory seems to be the main function of the hippocampus, part of the limbic system, whose activity and performance are closely linked with our emotional state.

Sleep:

During sleep, brain cells shrink, allowing toxins excreted during waking life to diffuse away that otherwise prevent clear thinking and learning, which can dramatically affect your ability to take in and process new information the next day.

Sleep is also directly important in learning material you have learnt not just in the last 24 hours but in the last couple of days, provided material has been “reactivated” each day. Neural patterns involved in new, problematic material in learning are formed in sleep and, conversely, less used synaptic connections (connections from neurone to neurone) are weakened, hence the importance of this reactivation, e.g. short practice of recently learned material.

Sleep has been shown to increase the ability to solve difficult problems and understand what you are trying to learn. It seems that the activity in the diffuse mode is programmed by what is done in the focused mode, so that material that someone thinks about before sleep is often dreamt about, particularly when such dreams are desired. These dreams aid understanding and consolidate the memory involved into easily-grasped chunks.

2: Chunks

Chunking

Chunking is a way to unite disparate information by meaning and helps to fit new information into pre-existing concepts, so you do not overwhelm working memory.

Working memory is important - the pre-frontal cortex links up new information to familiar regions during focused learning. The process does not work when you are angry, stressed or afraid.

How do you make a chunk?

- **See the pattern**

Give focused, undivided attention(working memory has limited slots available and you need them all), and work through material until you have a clear understandig!

- **See the bits**
    1. As you learn, it's important to see where the information fits, hence the value of looking at pictures and graphs! Work from larger to smaller scale.
    2. Check your recall of the key concepts: Closing the text and testing yourself will speed up your learning.
    3. The first time you know you really understand something is when you can recall it (or explain it) without any assistance. Doing it yourself establishes the neural pattern that underlies mastery.
- **Put the bits together**
    1. Understanding is necessary to make a useful chunk! But understanding is not enough - a chunk that can be recalled needs more than “aha” - it needs

review.
2. Practice ⇒ Gaining context: repeat and practice with related and unrelated problems to see how the newly-formed chunks fits into the bigger picture, and both how and when to use the new tool.
3. Practice helps broaden the network of neurones that connect to your chunk.
4. Bottom-up (repetition of basics) strengthens the chunk; top-down (context) shows where it fits in.
5. Context is where the bottom-up and top-down methods meet.
    1. The bottom-up aspect tells you how to use the information.
    2. Top-down methods tells you when.

Conserving space

When concepts have been connected into a chunk, they now just occupy one of the four slots of working memory that is easy to use to make new connections and leaves more space in working memory for other information / problem-solving.

The sky's the limit

- The ability to combine chunks in new and original ways underlies a lot of historical innovation. Bill Gates and other industry leaders set aside extended week-long reading periods so that they can hold many and varied ideas in mind during one time. This helps generate their own innovative thinking by allowing fresh in mind not yet forgotten ideas to network amongst themselves.
- To enhance their knowledge and expertise people gradually build libraries of chunks in their mind. Chess masters, actors and musicians all memorise huge amounts of sequences or moves, words or notes that are called to mind as required.
- Chunks also help you understand new concepts. This is because when you grasp one chunk, you'll find that that chunk can be related in surprising ways to similar chunks, not only in that field, but also in very different fields. That's one reason that a university degree in one subject can be a good training for working in a field that at first seems unrelated. One example is language learning and computer programming.
- A chunk is a way of compressing information compactly. A library of concepts and solutions internalized as chunks is like a collection or a library of neural patterns. The bigger the library, the more connections that can be accessed in the diffuse mode.
- To make the chunks firm and readily available, practice is necessary. In other words, deliberate practice - spaced repetition, problem solving, explaining to others.
- In building a chunked library, the brain learns to recognize not only a specific concept, but different types and classes of concepts that make it easy to quickly find appropriate solutions to new problems, and also to find new problem-solving strategies.

- However, there are still problems that cannot be solved in one sitting, but need a break away doing something completely different to get the diffuse mode working. However, the law of serendipity is important - the harder the initial the attempt, the more persistent you are with it, the better the chance of a Eureka moment.

Chunking - Summing it up

1. Chunks are pieces of information, neuroscientifically speaking, that are bound together through use and often through meaning.
2. You can think of a chunk as a scintillating network of neurons that compactly synthesizes key ideas or actions.
3. Chunks can get bigger and more complex. But at the same time, they're a single easy to access item that you can fit like a ribbon into the slot on your working memory.
4. Chunks are best built with focused, undivided attention, understanding of the basic idea. And practice to help deepen your patterns and to help you gain big picture context.
5. Simple recall, trying to remember the key points without looking at the page, is one of the best ways to help the chunking process along. It seems to help build neural hooks. They help you better understand the material.
6. Also try recalling material in places that are different from where you originally learned the material, so it becomes more deeply ingrained and accessible, regardless of what room you're in. This can be very helpful for tests.

Transfer is the idea that a chunk you've mastered in one area can often help you much more easily learn chunks of information in different areas that can share surprising commonalities. Interleave your learning by practicing your choice of different concepts, approach, and techniques all in one session.

Chunks are very important, but they don't necessarily build flexibility, which is also important in becoming an expert with the material you're learning.

3. Illusions of competence in learning

Seeing the solution and thinking you have solved the problem is one of the commonest illusions of competence in learning. Information must persist in memory in order for material to be mastered enough to do well on tests.

Overlearning

Overlearning can be very valuable when you have to get each little thing right when under stress, e.g. if you are a diver in a diving competition. However, research has shown it can be a waste of valuable learning time for most tasks. Worse yet, strengthening and deepening individual neural patterns can also bring an illusion of competence that you know a wide range of material

when you are really just expert in one small area.

Rigidity

This is related to a concept known as *Einstellung*. In this phenomenon, a fixed group of ideas can make become the only answer you have to a problem, blocking access to a new place where a better solution might be found. As the saying, if you are a hammer, everything looks like a nail. One kind of mistake students make is jumping into the water before they learn to swim. In other words they blindly start working on homework without finding out all the necessary information - from notes, the textbook, the teacher or knowledgeable colleagues. That can mean doing it more or less at random and creating confusing groups of ideas in the process.

Don't leave your brain on autopilot

- Highlighting and underlining suffer not only from fostering the illusion of competence but can also be misleading.
- It is best to only underline things after picking out the main points in the whole text.
- Re-reading is much less effective than recall
- Rereading does work, however, when time passes between the two readings so that it functions like spaced repetition.
- Concept maps do not work so well until the basic information is embedded in the brain.

A summary of illusions of competence in learning.

- Mistakes are a good thing to make when you're learning. They allow you to catch illusions of competence.
- Avoid practising only the easy stuff, which can bring the illusion that you've mastered the material.
- Deliberately practice what you find more difficult to gain full mastery of the material.
- Einstellung is when your initial thought, an idea you've already had in mind, or a neural pattern you've already developed well and strengthened, prevents a better idea or solution from being found, or keeps you from being flexible enough to accept new, better, or more appropriate solutions.
- The Law of Serendipity is helpful. Lady Luck favors the one who tries. Just pick one tiny thing out to learn, then another. Just keep trying and you'll be pleasantly surprised at the results.

4. Effective learning

We have looked at focused and diffuse modes, chunking and avoiding illusions of competence. There are particular learning skills that put this all

together.

Mini-testing

Test yourself: the value of making mistakes (Karpicke and Blunt, *Science* 11 Feb 2011: Vol. 331, Issue 6018, pp. 772-775)

- Students learn far more and at a much deeper level when they sandwich recall between 2 readings despite not spending more time
- An open book provides an illusion of the locus of the knowledge (I know where it is therefore I know it)
- Formal and informal tests were equally effective.
- Recall is particularly useful outside the environment in which one learnt the material to ensure independence from cues related to that environment.

Tips to consolidate your learning

- Learn to recognize when you're fooling yourself about whether you're actually learning the material.
- Test yourself frequently using little mini-tests to see whether you're actually learning the material, or whether you've been fooling yourself, thinking you're learning when you're actually not.
- Recall is actually a form of mini-testing.
- Try to avoid depending too much on highlighting, which can fool you into thinking that the material is going into your brain when it actually isn't.
- Mistakes are a good thing to make obvious the thinking flaws and show how efficiently one is learning.

5. Tackling procrastination

- It's easier, and more valuable, than you think
- Zombie responses are often focused on making the here and now better. You can trick some of these zombies into helping you fend off procrastination when you need to.
- Not all procrastination is bad - there may really be a good reason for not doing this thing, now - but it needs to be a decision and not a habit
- Learning to avoid procrastination is important: good learning is a bit by bit activity.
    - You want to avoid cramming which doesn't build solid neural structures.
    - By putting the same amount of time into your learning but spacing that learning out by starting earlier you'll learn better.

Process, not product

Researchers have found that non-procrastinators put their negative thinking aside, finding a way just to get started. One particularly

powerful technique is to focus on process not product, in other words let the time flow along with the habits and actions associated with that time. Product is an outcome, for example a report you need to finish.

- Processes relate to simple habits, habits that coincidentally get through the least favourite tasks to be done, for example, where homework in a particular class is not enjoyable. The point is that the time is given over to the work itself, and not the outcome.
- Thinking about the outcome just brings about negative feelings. Being involved in a process moment-by-moment without thinking of the outcome avoids these feelings. The important thing is not that the homework is finished - when the time is over, perhaps there is still some work left over - but a lot less than at the start!

Unlike procrastination which is easy to fall into, willpower uses a lot of neural resources. You shouldn't waste willpower on fending off procrastination except when absolutely necessary. But don't underestimate the damage procrastination causes: that impulse to switch from something boring, painful or difficult makes it impossible to learn properly, so the material gets more boring and difficult, and the issues of learning get more painful!

An overview of tacking procrastination:

1. Keep a planner journal so you can easily track when you reach your goals and observe what does and doesn't work.
2. Commit to certain routines and tasks each day. Write your planned tasks out the night before so your brain has time to dwell on your goals and help ensure success.
3. Arrange your work into a series of small challenges.
4. Always provide rewards. Take a few minutes to savour them, which also gives your brain a chance to temporarily change modes. But deliberately delay rewards until you've finished a task!
5. Watch for procrastination cues. Try putting yourself in new surroundings with few procrastination cues, such as the quiet section of a library.
6. Gain trust in your new system. You want to work hard during times of focused concentration and also to trust your system enough so that when it comes time to relax, you actually relax without feelings of guilt or worry.
7. Have back up plans for when you still procrastinate.
8. Eat your frogs first every day.

6. Research and neuroscience

Creative brains

There's an interesting connection between learning maths and science and learning a sport. Practice creates muscle memory, so your body knows what to do from recalling one chunk instead of having to recall all the complex steps involved in kicking a ball. In the same way you can imagine gas molecules moving by diffusion through a membrane rather than having to think about random motion, kinetic energy and concentration gradients each time.

By doing many problems involving the same ideas you come to understand them much better than by getting a conventional explanation from a teacher or a book. It can also be useful to link up ideas from one topic and see how they fit another one. For example, the word diffusion is also used to refer to ideas spreading through a population, so you might ask yourself in what ways this analogy works and in what ways it doesn't (do ideas have kinetic energy or random motion? - that doesn't work too well; but on the other hand where an idea is popular - high concentration - you would expect it to move faster, and if you could somehow picture the idea using a satellite, it might look like ink diffusing in water…). Thinking like this helps recall the definition and of diffusion and its effects in the physical sciences, and it might also help critical thinking in social sciences to reflect on how ideas are spread by different media.

The main thing is to use the brain you have - our ability to learn is not especially a function of “IQ” but much more of good habits and determination. Being “smarter” often equates to having a larger working memory, perhaps one that can hold nine things instead of four and so someone can link together concepts much more easily. But that can also make it more difficult to be creative by blocking other things going on in the mind. *Einstellung* can result, blocking new connections to the chunks that are now formed. On the one hand, smartness can lead to better focus and less daydreaming. On the other, isn't creativity at least as important - and perhaps more enjoyable for all concerned?

3 things about memory:

1. visio-spatial memory is very efficient: it can be used to add encoding to new ideas being memorized
2. spaced repetition is useful
3. flash cards!!! (with diagrams)

In the end, though, it is deliberate practice that builds real learning. Not only do less academic brains get there in the end, but they can also build up a richer conceptual world out of the new material. The important thing is to appreciate the experience.

Dr. Terrence Sejnowski

One of the teachers on the course, specialising in the neurobiology of learning - his tips and useful references are below

Ask questions

Think about it when you are doing exercise and take notes before showering! Multitasking is not really possible; what people actually do is “context-switching”, which some people do better than others

Something new in neuroscience that is useful?

Unusually, in the hippocampus new neurons are produced throughout life, and in an enriched environment their interconnections are much stronger - and exercise in particular will increase this. One particularly useful aid to learning is being in a creative environment. Trying to explain ideas is particularly helpful to the creative process.

Serotonin and Orexin

Serotonin Differentially Regulates Short- and Long-Term Prediction of Rewards in the Ventral and Dorsal Striatum
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2129114/

Humans Can Adopt Optimal Discounting Strategy under Real-Time Constraints http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1635539/

Differential behavioral effects of plasma tryptophan depletion and loading in aggressive and nonaggressive men.
http://www.ncbi.nlm.nih.gov/pubmed/10700655

Orexin/Hypocretin: A Neuropeptide at the Interface of Sleep, Energy Homeostasis, and Reward System
http://pharmrev.aspetjournals.org/content/61/2/162.full#title19
(wikipedia on orexin suggests it causes wakefulness and hunger, and is suppressed during chronic sleep deprivation