Learning How to Learn: A Guide for Teachers

Introduction

The purpose of this document is to share current, research-supported findings about how people learn. I created this guide by distilling the learning research and advice presented by Dr. Barbara Oakley and Dr. Terrence Sejnowski, instructors of the *Coursera* MOOC (Massive Open Online Course), *Learning How to Learn,* offered by The University of California, San Diego. If you find this information about learning compelling, I highly recommend Dr. Oakley's book, *A Mind for Numbers*, upon which the course was based. Although it appears to be geared towards math and science from the title, the book applies to learning of all skills and disciplines.

While working through the course content, I thought about the advice that I give my freshmen students before final exams in January: "Space out your studying -- don't wait until the last minute and cram; make sure you get enough sleep; don't spend a lot of time studying things you already know well, etc."

As I advanced in the *Learning How to Learn* course, I realized that although this is sound advice, the way that I have counseled my students is ineffective. First, I didn't provide my students with reasons for why these suggestions are valuable. No one appreciates hollow advice. Secondly, providing this advice at the end of the semester is five months too late. Teaching my students how to study is something that I should address at the start of the year so that each student has the opportunity to improve their study methods and to learn more deeply (in all of their classes) from the beginning.

And that leads me to why I created this document. As I "learned about learning", I realized how much I previously didn't understand. I imagine that many teachers are in the same boat, and from experience I know that many students do not study effectively. I believe that this information is invaluable to teachers in influencing our methods of instruction, crafting homework assignments, and -- most importantly -- in helping our students form strong learning habits. For years, educational research has demonstrated best instructional practices that facilitate learning most effectively, and now due to advances in neuroscience, much is understood about how the brain works during learning. Understanding how our brains learn provides us with a framework for approaching teaching and learning. Armed with this powerful information, we can adapt our instruction to support students in best learning practices. Here are a few questions that I invite you to ponder as you read this guide:

1. How can I use this information to construct learning experiences that promote deep learning for my students?
2. How can I share this information with my students so that they may adopt effective learning habits and strategies?
3. How can I craft homework assignments that reflect and encourage successful learning strategies?
4. How can I employ these strategies to enrich my own learning?

I have created a student guide for this information, which I plan to give to my students at the beginning of the year so that they may start forming effective learning habits immediately. I invite you to use these guides however you deem meaningful for your learning and teaching, but I encourage you to share it with your students in some way.

Tom Flanagan

Neuroscience Teaches Us about Learning

Understanding learning requires an understanding of how the brain works. You do not need to be a neuroscientist to understand how people learn, but discoveries in the field provide compelling evidence. Just a shallow understanding of the brain's basic biology helps us to comprehend profound truths about learning.

1. The brain is a bundle of neurons. The brain is composed of specialized cells called neurons (aka nerve cells). Neurons communicate with other neurons by connecting and transmitting electrochemical signals (nerve impulses). Multiple neural connections create a network of neurons that can send messages between one another.

2. A neural pathway is the physical manifestation of learning. A neural pathway is a specific circuit of neurons within the neural network that are accustomed to firing together (Oakley, 2014). When messages are repeatedly sent through the same sequence of neurons, the connections among these neurons grow stronger. The stronger the neural connections, the more adept the brain becomes at accessing and utilizing the information or skill associated with that pathway. Different neural pathways are accessed when one practices a piece on the piano, works on solving a math problem, or rehearses a speech. In fact practicing a different musical piece, solving a different math problem, or rehearsing a different speech will access different pathways still. The more that a particular neural pathway is called upon and utilized by the brain, the more easily it can be accessed in the future, and thus the deeper the learning. This is why "practice makes permanent" (more on this later).

3. Conceptual "chunks" are stored in the brain's neural pathways. The actual circuit of firing neurons is the neural pathway, and the skill, concept, or technique that the brain can recall from the circuit is called a chunk. So, for clarity moving forward, the word "chunk" refers to the information that the neural pathway embodies.

4. Brains DO produce new neurons throughout life. Many of us have heard that you are born with a given amount of brain cells and although many will die along the way, your body will never manufacture new ones. This turns out to be flat out wrong, and was news to me as a biology teacher too! Neuroscientists have discovered that the hippocampus, a part of the brain instrumental in learning and memory, makes new neurons throughout one's life...even during adulthood (Sejnowski, 2014). And what stimulates the production of these neurons?

1) An enriched, engaging learning environment and
2) Exercise (more about this later) (Sejnowski, 2014).

This discovery is truly profound for what it teaches us about teaching, learning, and intelligence. According to Dr. Carol Dweck, most people ascribe to one of two theories of intelligence -- the entity theory or the incremental theory. Basically, entity theorists see intelligence as a fixed entity, while incremental theorists see intelligence as a dynamic, changeable capacity (Plucker, 2013). When we encourage our students to pursue improvement and to develop a love of learning, we are supporting the incremental view. The biological fact that our brains continue to produce new neurons and thus new neural pathways throughout life, is evidence that intelligence is malleable. Just because we are not good at something today, doesn't mean that we cannot become expert at it in the future. Dr. Oakley sums it up best when she states that learning how to learn empowers one to not only pursue one's passions, but to discover and develop new ones (2014). What a wonderful perspective to pass onto our students!

The Two Modes of Learning: Focused and Diffuse*

When we think about learning something new, we often think about the focused concentration and attention that is required to master that concept. Indeed, this focused mode of learning is an important component of learning, but of equal importance is the less well known diffuse mode. We engage in the diffuse mode when we are NOT focused on the content that we are trying to learn or the problem that we are trying to solve. By exerting less focused effort, the unconscious neural networks of the brain "work in the background" on the problem even though we are not consciously thinking about it (Oakley, 2014). While new neural connections are made in the brain, actual learning connections are made. This is why "sleeping on it" sometimes brings more clarity or an aha moment the next day.

Examples of diffuse mode activities:

- Taking a walk, going for a jog, etc.
- Sleep (Sleep is the ultimate diffuse mode and is crucial to learning; more on this later)
- Listen to music
- Text, talk with friends

Anything that doesn't involve focused attention supports the diffuse mode, so as you can imagine from the list above, some are better than others in accessing the diffuse mode. We learn new information most effectively when we give our brains opportunities to bounce back and forth between the focused and diffuse modes (Oakley, 2014). So, when we tell our students to "Study for a little while and then treat yourself to a break." this is excellent advice supported by neuroscience!

Learning Strategy: *First engage in focused mode learning before moving to the diffuse mode.*

The "learning seed" must be planted during the focused mode so that it can be nurtured and cultivated during the diffuse mode. (Oakley, 2014)

**Note: In the student guide, you will notice that I substituted "siesta mode" for "diffuse mode". I did this because I think students will relate to this nomenclature better.*

Chunking

Dr. Oakley explains that "when learning something new, you're making new neural patterns and connecting them to preexisting patterns in multiple areas of the brain" (2014). In order for new information to "stick", it must be 1) practiced and 2) connected to prior knowledge/experience. When this is accomplished, the new neural pathway is fortified and linked to other established neural pathways. Now, the new neural pathway is more easily accessed by the brain and it will be available when other mastered information is retrieved.

Learning Strategy: *How to Form a Chunk*

1. *Focused study of the information*.

2. *Achieve an understanding of the main idea*. Use the back-and-forth practice of engaging in both focused and diffuse modes to understand the big picture.

3. *Practice*. Practice with that information to "gain mastery and a sense for when to use this chunk and how it connects with previously mastered knowledge" (Oakley, 2014)

Knowing how chunks are formed helps inform our teaching. We can help our students learn more effectively by structuring our class' learning experiences so that we build upon prior knowledge and by allowing students to grapple with/practice with the big picture idea before filling in the details.

Practice Makes Permanent

Research (both from education and neuroscience) demonstrates that individuals learn best when they practice the skill, problem-solving technique, etc. This is because the neural pathway that comprises that skill in the brain is strengthened with repetition. To move information from your working memory (which is like a temporary whiteboard in your brain) to long term memory (where learned material is permanently stored), requires time and practice (Oakley, 2014).

Learning Strategy: *Spaced Repetition*

Extend practice of the skill/learning content over several days. Cramming the night before the test is the opposite of spaced repetition. Repeating the skill/content four times per day for five days will result in superior learning compared to repeating the skill/content twenty times the day before the assessment (Oakley, 2014).

Active Learning > Passive Learning

Pedagogical research provides empirical evidence which demonstrates that student-centered, active learning experiences maximize learning better than passive ones (Freeman et al., 2014). Once again, this conclusion is supported by our understanding of how the brain learns. An enriched, engaging learning environment increases the production of neurons and actively practicing skills or utilizing content fortifies the underlying neural pathways. Just as active learning strategies improve learning in the classroom, they are also superior for studying and reading.

Learning Strategy: *Practice retrieving information from your memory.*

1. *Test yourself.* The act of retrieving learned/read information is a powerful brain activity which strengthens the associated neural pathways. Testing yourself is a potent way to practice retrieval and deepen your learning. Testing can take multiple forms (such as recall or answering questions on a study guide), but what is crucial is that the learner is actively solving the problem/working with the material. When testing is done via spaced repetition, neural pathways are strengthened to achieve neural patterns of mastery (Oakley, 2014).

2. *Practice recall/retrieval in different environments.* Studies show that by retrieving learned information in places away from the normal learning space, one does not become dependent on cues from a singular environment (Oakley, 2014).

3. *Mix it up*. Interleaving is the practice of retrieval while mixing up the types of problems or the order of the questions/content being studied. Skipping around may feel like it makes learning more difficult, but it helps one learn more deeply as it improves recall by developing flexibility and creativity in thinking (Oakley, 2014). Interleaving between different subjects can help one to make interesting, creative connections between disciplines. *Remember: more connections = stronger neural pathways = deeper learning.*

4. *Spend more time on the hard stuff.* Practicing more with the difficult material gives your brain the time and repetition it needs to make the proper connections to conquer difficult material. Spending time on studying stuff you already know is a waste of time for two reasons: 1) you already have strong neural pathways for that info so they don't need to be fortified further and 2) studying what you already know may create an *illusion of competence* (Oakley, 2014).

Learning Strategy: *Combatting Illusions of Competence*

An illusion of competence is the feeling that you know the full breadth of material when your understanding is actually limited.

Study habits that cause/reinforce illusions of competence:

1. Re-reading notes.
2. Highlighting text.
3. Studying what you already know.
4. Holding onto a previous thought or explanation that prevents new, better ones from taking hold.

Study habit <u>solutions</u> to illusions of competence:

1. Test yourself.
2. Minimize highlighting.
3. Deliberate practice: study the hard stuff more than the easy stuff.
4. Make mistakes and identify your misconceptions. Then, unlearn those misconceptions, by replacing them with correct understanding (Oakley, 2014).

Learning Strategy*: How to Actively Read a Textbook*

1. *Scan before reading*. Before beginning to read, scan the assigned pages by reading all section headings, diagrams/figures and their captions, and the review questions.
2. *Predict.* Explain to yourself (better if done on paper) what the section is going to be about.
3. *Read.*
4. *Minimize highlighting.* Highlighting is a good way to trick yourself into thinking that you know the information. People may think what they highlight is going into their memories, but often it remains on the page after being scanned by our eyes. Annotating the text by making notes in the margins is much more effective (Oakley, 2014).
5. *Recall*. While reading, occasionally pause and try to recall the main ideas/big picture that you just read about. Writing down your answers is important so that you can go back and check them, which is a crucial step. At the end of the reading task, again attempt to recall the meaning of what you read and check your answers. Recall is a form of testing yourself, and has been shown to be much more effective than re-reading and concept-mapping in improving one's understanding of new material (Oakley, 2014).

Thwarting Procrastination

Neuroscientists have observed that when people are faced with a task that they don't feel like doing, the pain center of the brain is activated, which explains the uncomfortable feeling about the task (Oakley, 2014). To ease this pain, the brain seeks distraction by instead focusing on something that will not elicit a painful stimulus. So, the individual stops thinking about the first task in favor of an activity that will bring gratification (Oakley, 2014). This is why we procrastinate -- it is literally a pain avoidance strategy. However, neuroscientists have also found that if an individual engages in the first (pain-inducing) task, the pain-registering part of the brain shuts off fairly quickly. So, if a person can engage with that task for a short period of time (usually a couple of minutes), then they won't feel the discomfort for long and the brain will not try to actively distract its focus (Oakley, 2014).

***Learning Strategy**: Solutions for combatting procrastination*

1. *Acknowledge to yourself that it's normal to not want to do certain tasks.* But tell yourself, "If I buckle down and get into the work, I'll feel better soon." (Oakley, 2014)

2. *Focus on process instead of product.* Focusing on the final product (ex. the finished assignment) is what causes us discomfort. Instead of focusing on finishing the product, we should commit to spending a certain amount of time engaged in the process of completing it (Oakley, 2014). Setting a goal of putting in 25 minutes of work on the paper is less intimidating than thinking about finishing the paper.

The Pomodoro Method: A Process over Product Technique

1. Remove <u>all</u> distractions (find a quiet place; turn off phone, TV, computer, etc.)
2. Set a timer for 25 minutes.
3. Study with intense, complete focus on your learning task for 25 minutes.
4. At the conclusion of the 25 minutes (whether or not the task is complete), stop the focused learning and move to diffuse learning by taking a break. During this break, reward yourself with something enjoyable (Oakley, 2014).

Ways to increase the efficacy of the Pomodoro Method:

1. *Eliminate distractions in your study space.* Usually some kind of cue -- an incoming text, a TV show on in the background, etc. -- is what your brain lunges for when it wants to get distracted. When it is time to put in 25 minutes of focused work, eliminate these distractions.

2. *"Eat your frogs first".* Work on your least favorite assignment first.

3. *Stick to the plan.* It's never easy to break a bad habit like procrastination, but it's important to stick to the plan of doing the short, 25-minute focused study sessions. Don't beat yourself up if you have a procrastination relapse. Keep trying to commit to this new routine.

4. *Believe that you can conquer procrastination!* As with any goal, you will only accomplish it if you believe that you can.

The Pomodoro Method supports effective learning while combatting procrastination. If the student commits to focusing on the task for a manageable time period, he/she will actually sit down to attempt this task that they do not feel like doing. After a couple minutes, they will be focused on the task rather than their negative feeling towards the task. Also, this strategy incorporates the alternation between focused and diffuse modes, which is critical for deep learning.

Sleep is Important!

How often have we heard students talk about pulling all-nighters or lamenting the fact that they only got a couple hours of sleep because they were finishing a paper or studying for a test? It often seems that sleep is given little priority and deemed expendable. When it comes to learning, nothing could be further from the truth. Here's why:

1. **Brain toxins are removed during sleep.** While awake, neurons produce toxins as a result of the chemical reactions that they are constantly performing while doing their jobs. Thinking, concentrating, learning...*all* brain activities are compromised in the presence of high toxin load in the neurons. It is during sleep that these toxins get flushed away (Oakley, 2014).

2. **Sleep strengthens neural connections.** Sleep is the ultimate diffuse mode activity. During sleep, the brain builds stronger neural connections of practiced pathways so that the skill/content associated with these pathways will be more permanently ingrained in our long term memories. The brain also prunes back weak, unnecessary neural connections, associated with unimportant information (Oakley, 2014).

3. **Your brain works on complex, difficult solutions during sleep.** During sleep, your brain rehearses difficult problems and material that you were previously grappling with in your focused mode. During the diffuse learning mode that takes place while sleeping, multiple parts of the brain communicate with one another, causing complex neural pathways (associated with creative, complex ideas) to be solidified in the brain (Oakley, 2014).

Learning Strategy: *Review/think about what you want to learn right before you go to sleep.*

Studies have shown that if you think about something before sleeping, you have a better chance of dreaming about it, and dreaming about something has been shown to help you learn it (Oakley, 2014). Remember that you must first practice focused mode learning before diffuse mode, so sleep will only help you learn if you've practiced with the information in the focused mode first.

Exercise is Important!

As stated earlier, exercise has been shown to produce new neurons. And it doesn't take a rocket scientist (or a neuroscientist) to figure out that more neurons mean more neural connections and thus more learning.

Exercise is actually like a two-for-one deal. Not only does it spur the production of new brain cells, but it also is a great diffuse mode learning activity. Many forms of exercise do not require intense focus, so engaging in exercise allows the brain to wander into the creative diffuse mode where what you learned during the focused mode is strengthened and refined.

References

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