

MAIN PRINCIPLES OF TEACHING aka HOW THE BRAIN WORKS

Opening questions for the reader before reading:

- How would you define learning? What is it?
- What feelings do you associate with learning?
- Which learning/teaching methods are effective and which are not? Why?
- Can we use the same methods in schools as in a business setting? Why or why not?
- How have you studied and taught in your life? Do you think you have done it effectively? Do you think you have been taught to do it effectively? How do you know?
- What are some good ways to make information stick to our brain permanently?

This chapter is largely based on the work done by many educational psychologists, see references in the footnote^{1,2}

Our brain is a wonderful organ – one of its amazing characteristics is its [neuroplasticity](#). This means that we can actually change our brains by learning new things. But there are also many illusions about how effective learning happens. This means our intuition about learning is not always telling the truth.

WHEN DOES LEARNING HAPPEN?

From the list below which conditions/activities do you think are vital for learning, which are nice to have but not necessary, and which are not helpful and why?

- Giving rewards (grades, bonuses, free days from school/work...)
- Making mistakes
- Learners being out of their comfort zone
- Giving safe space
- Only theory
- Only practice (solving a problem)
- Theory first, then practice (solving a problem)
- Practice first (solving a problem), then theory
- The topic is relevant to the learner, they see the benefit and connection with their work
- Gamification, edutainment
- Making sure the tasks are not too difficult
- Making sure the tasks are not too easy
- Lots of visual and video support
- Making jokes during the lesson
- Strict rules set by the educator
- Free flow of discussion
- Structure and rules given by the educator in the beginning of the lesson
- Using majority of the lesson just to discuss with learners, with little time to present the theory and slides

Make your choices, some of them are indeed quite tricky and can depend on several things. See if you get the answers from the rest of the text.

¹ Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual review of psychology*, 64, 417-444.

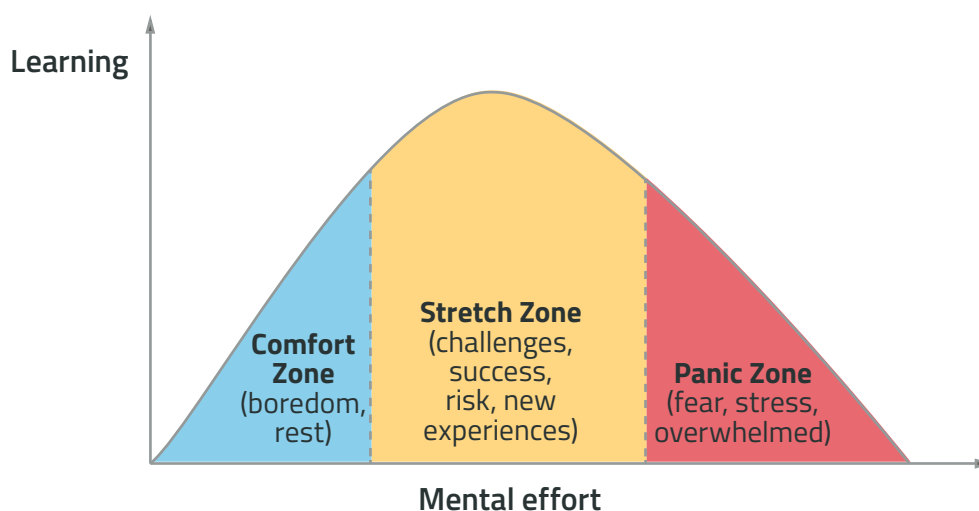
² Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). *Make it stick*.

Should learning be easy and fun?

There is so much focus on games and entertainment in education nowadays, making us believe this is how learning should be. Learning can be fun, but this should not be the only aim. The true feeling of learning something new is in fact the feeling of **being confused, feeling stuck, not being sure what to do, and putting in effort to get your head around the material or solving the problem** – this is the starting point of learning! When things come too easily for us, it means we are not really learning – maybe we are doing things we already know how to do; or maybe we get the concept too superficially or have “beginner’s luck”. Learning means effort for the brain – new connections (synapses) are formed between neurons and some connections can be changed, and that does not come easily. We can imagine that learning is like building new roads between places where there were no roads before – it’s a lot of work! And in the same way, making this newly acquired knowledge permanent in the brain means that these roads need to be used again and again (retrieving/recalling the knowledge time after time).

If we only focus on the games, jokes and flashy visuals, without thinking through how they serve the purpose of your lesson, and without asking, who does the deep and thorough thinking, learners or educator, then they may simply be a distraction and can create an illusion for you as an educator, because you might mistake the learners’ enjoyment of the session for learning.

There is a quite famous graph about the comfort, stretch and panic zone, which shows in what state learning happens:



Source: Karl Rohnke; Yerkes-Dodson Law

At the same time it’s also important to remember that a stressed brain cannot learn anything, especially complex stuff, as it goes into survival mode and the part of the brain which supports the complex thinking, switches off.³ This means that there must be a sense of emotional security and comfort in the learning setting, while creating mental effort and stretching.

³ Hohnen, B., & Murphy, T. (2016). The optimum context for learning; drawing on neuroscience to inform best practice in the classroom. *Educational & Child Psychology*, 33(1), 75-90

Learning needs:



- **Mental stretching** (thinking)

Tasks that make you think just hard enough, when answers don't come right away



- **Emotional comfort** (feeling)

Not fearing the teacher or fellow-students, feeling it's ok to make mistakes

How do we create mental effort?

Mental effort can most easily be created by having to solve a problem. There are many different ways how problem-solving can be structured in a lesson.

We offer here two different approaches:

1. **Direct instruction design** – learners are first presented with the instructions and then given a problem to solve. This is often the traditional way we are being taught.
2. **Productive failure design** (with delayed instruction) – learners are first asked to solve a problem without giving them instructions how to solve it. After trying, activating what they already know, experimenting and perhaps failing once or several times, the instructions are introduced, discussed and reflected upon.

Which one is more effective?

As stated above the learners have to struggle a bit before they are presented with the answers and right ways to solve the problem. They have to:

- First **realise themselves** that they don't know how to solve the problem,
- Acknowledge that they are missing this knowledge/skill and
- Understand that they want to get this new information to be able to solve the problem better.

So the productive failure design⁴ is more effective. This is one example of what is called a **desirable difficulty** – something learners can overcome through increased effort, and what will be helpful to master that specific skill or knowledge.⁵ Desirable difficulty is the effort we need in the learning situation.

⁴ Jacobson, M. J., Markauskaite, L., Portolese, A., Kapur, M., Lai, P. K., & Roberts, G. (2017). Designs for learning about climate change as a complex system. *Learning and instruction*, 52, 1-14.

⁵ Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). *Make it stick*.

Why are mistakes important?

First of all, it's important to recognise that we as humans are often (a)shamed of our mistakes, because we think it's considered a weakness. Unfortunately, this is often transmitted into learning-teaching situations as well. You can simply think of yourself the last time you made a mistake and how it made you feel.

But mistakes are one of the most valuable [tools of learning](#) – the moment of analysing and processing the mistakes is the moment when we actually learn the most. Mistakes are where we get feedback on what works and what doesn't and where we need to practice more. In fact learning cannot happen without trial and error. Nobody can know the right answer right away; most of the world's complexity we cannot figure out ourselves anyway. Shaming or hiding mistakes can actually lead to only shallow learning, misconceptions and all other troubles. Instead we should welcome mistakes as gifts of useful information – both our learners' and our own mistakes.

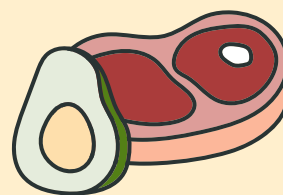
But most important to remember is that the **mistakes need to be reflected upon**, analysed, processed, studied – only then will the mistake be repaired and deep learning occurs.

MEMORY

Getting things to stick in our memory is a big part of learning. And obviously we want the zero waste knowledge to stay in our learners' memory for a longer time, not just for a week. In order to do that, we need to know how lasting memory traces are created.

Consider this real life story:

"I wanted to teach about the environmental impacts of food. I showed the students images of 2 food items: beef and avocado and asked which has a bigger impact and why. Most of them said avocado, because it comes from far away and has a big impact from transport. I then showed them a graph, which illustrates how small the impact from transport is (6%) and that the main impact comes from how the food is farmed (land use, use of pesticides etc). Everybody looked surprised and it felt like a good wow-moment for me.



A month later, when I asked them to assess the environmental impact of different food items and how to lower that, many of them still focused on transport and even after showing the graph again, they still needed several questions/nudges from me to think about the land use impact."

What does it tell us about memory and how learning happens?

What could the educator have done differently?

First of all, the brain is not a voice recorder or camera that stores all the information that it hears or sees. Instead, it is a living and constantly changing network of interacting neurons that represent the memories we have. Our brains pick up information from everywhere, and each of us has a unique set of knowledge, opinions and understandings collected into our minds. And the way new information can find its way to our memory is when we attach it to already existing bits of information – our pre-knowledge. **We only remember things that we have been able to connect to with something already in our memory.** And we store this new information in terms of its meaning to us, as defined by its relationships and semantic associations to pre-knowledge.⁶

A comparison could be networks between people. How do you form new friendships? How do people find themselves into your network of friends? There is usually something that connects that person with you that makes it worth building a longer and stronger bond. It is similar to new knowledge finding its place in our brains.

A good knowledge or skill is described as (and what we want zero waste knowledge/skills to be):⁷

Durable – remembering things also months or years after last using the knowledge.

Flexible – being able to put the knowledge into different contexts, being able to see the same mechanisms and principles in new situations and applying them there.

The process of creating a knowledge or skill happens roughly in three stages:⁸

- 1. Encoding** – connecting the info with existing knowledge in the learner’s brain, making it meaningful for the learner – this should happen during the learning activity, so there should be time for that (meaning we cannot fill our sessions only with our own talk and presentations).
- 2. Consolidating** – securing the new information in the learner’s brain. This can happen after the learning activity, where learners can fully connect the new info with their pre-knowledge, organise those connections, fill in the blanks – but this means the learner will actively think about the content of the lesson after it has finished.
- 3. Retrieval** – this should happen after there has been time to forget the lesson. Retrieval is essentially training the memory trace to that information – the more times (with forgetting breaks in between) we retrieve the information, the stronger the memory trace becomes. Reflection is also a form of retrieval.



**What does this mean to us as educators? What does it mean to learners?
What do we need to include into our teaching?**

⁶ Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual review of psychology*, 64, 417-444

⁷ Soderstrom, N. C., & Bjork, R. A. (2015). Learning versus performance: An integrative review. *Perspectives on Psychological Science*, 10(2), 176-199.

⁸ Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). *Make it stick.*

Choose which retrieval strategies you think are the most effective:

- Massed practice – practicing for long hours
- Self-testing – trying to retrieve information from memory
- Interleaved practice – mixing up, changing between learning different topics and subjects
- Rereading
- Rewriting – making verbatim notes based on materials
- Conceptual mapping – making mind maps from the main ideas
- Testing (without grading)
- Rephrasing information in your own words
- Spaced, distributed practice – learning the same thing with pauses
- Variability of practice – learning the same concept in different contexts/situations
- Highlighting important parts of the material
- Relating the material with own experience or other subjects/topics
- Elaborative interrogation – asking yourself, how things work and then answering (more about what it is can be read from this [blog post](#))

For answers, you can check out this [TED talk](#) and check our list at the end of this chapter.

Why is forgetting and retrieving important?

In real life situations we don't know when we might need the learned information. A pilot will never know when they need to cope with a failing engine and emergency workers will not know what kind of aid they will need to give on a particular day. But that knowledge and skill has to be ready for use, even when it hasn't been used since finishing the training. It means we need to practice retrieving it. And we can only retrieve what we have (somewhat) forgotten.

The more we need to put in effort to retrieve (or relearn) something, the better we learn it. The more you've forgotten about a topic, the more effective relearning will be in shaping your permanent knowledge.⁹

LAST NOTE: TEACHING ABOUT LEARNING

Several things in this chapter might be different from what we are used to in teaching-training situations, meaning that many people have illusions about how learning should happen and they are often expecting something quite classical from training sessions. So when we start to put into practice different methods given in this chapter, it might make our learners (or clients who have paid for the training) grumpy and unhappy. And that's not the kind of confusion we want to have in our sessions.

⁹ Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). *Make it stick*.

This means that parallel to teaching people zero waste, **we also need to explicitly explain what effective learning means**, so that people would be more open to participate. It can be as simple as asking in the beginning of your session what learners themselves think how they could learn best in your session and even giving them a short list of options to choose from. For example:

- A. Listening to a lecture
- B. Listening to a lecture and making notes
- C. Discussion on questions connected to the topic
- D. Solving practical cases connected to the topic



This small exercise can be followed by a short intro how the session is built up and how it supports learning best.

SUMMARY

There are many things we need to take into account when planning and facilitating learning. It can be quite overwhelming when our own experience of learning has been often quite the opposite. So here's a small check-list to keep in mind:

Main things that need to be present in order for learning to happen

1. Learner's brain is active – only reading or listening is not enough!
2. Learner's thinking is made visible – there is interaction with the educator and between the learners.
3. Learner constructs new knowledge themselves – solves a problem, proposes solutions and predictions.
4. There are tasks where learner makes mistakes, so s/he can analyse them.
5. The tasks require effort in the brain – new connections are starting to form in the brain.
6. Learner gets feedback on their work and tasks from the educator – mistakes are reflected upon and corrected.
7. There is no emotional stress, tension or anxiety – brain can focus on learning.



The one who thinks and speaks (constructs knowledge) the most, learns the most. Should it be the educator or the learner? :)

Here are few of our practical tips for teaching zero waste and circular economy:

- Try to get as much info as possible about learners' understanding of the topic beforehand. Ideally it would be before the learning session, but you can also use the first part of your session asking what they know of the topic already or let them solve a problem connected to the topic. Then you can see where they lack knowledge and skills and adjust your session to their level of expertise.
- Don't show the Zero Waste Hierarchy or circular economy "butterfly" (or any other scheme, graph of a complicated system) – ask people to first draw it themselves or give pieces of the graph that they need to put together themselves – this way they are constructing the knowledge themselves. Afterwards you can show the official version and ask them to find differences and similarities with their versions. Same can be done for asking people to define the terms (circular economy, reuse, recycle...) themselves, before presenting the official terms. It's often that people think they know what these things are, but once they are asked to talk about them, they can realise they don't know it that well after all.
- Present them first with a problem: what would be the best management option for biowaste? How to improve recycling rates? Let them come up with their ideas and solutions, then discuss it with them, ask additional questions and only then show your solutions.
- Wait before giving your answers or solutions. First ask them questions that make them think about different aspects of their proposal and that finally could lead to your solution. Ideal would be if they can reach the same solution that you as an expert would propose, themselves. A well-phrased question always teaches better than a well-phrased expert answer.
- A practical way to delay your expert answers is to add an extra empty slide in your presentation. Copy your original slide with information and then delete the main content, just leaving the title/main question. Ask the learners what they think should be there? After their ideas and discussion show your original slide with your thoughts.



Can you think of any other good examples? Let us know if you do :)



Here's the list of the retrieval practices grouped based on their effectiveness.¹⁰

Useful practices and why?

Useful practices are:



- Self-testing, retrieval practice
- Interleaved practice
- Spaced, distributed practice
- Variability of practice
- Rephrasing with your own words (but preferably after a pause; actually it is more a consolidation strategy)
- Relating the material with own experience or other subject/topics
- Elaborative interrogation

These practices are effective because they demand effort and an active reconstruction of the learned material. They assume activation of the material – information is to be retrieved from long-term memory, almost like giving the brain the signal that this information may be needed also in the future. They may be more effective when done in written form, because we are more precise in our words then and it's easier to notice if some information is still vague or unclear.

Not so useful practices and why?

Not so useful practices are:



- Massed practice, practicing for a long time
- Rereading
- Rewriting

They are not very useful, because they demand little effort, and tend to create the illusion of knowing/mastering the material, as it keeps circulating between our short term memory and our active processing "workspace" (which is called working memory, which is actually not a space, but a process). As the material is not retrieved, that is, activated from the long-term memory, the brain does not learn how to find this information from memory.

So-so usefulness and why?

So-so practices are:



- Conceptual mapping – could be useful as encoding strategy, which is done quite often in the beginning of learning;
- Highlighting important parts of the material – demands little effort, creates the illusion of learning; can be useful for sophisticated learners or short-time learning goals though.

¹⁰ Soderstrom, N. C., & Bjork, R. A. (2015). Learning versus performance: An integrative review. *Perspectives on Psychological Science*, 10(2), 176-199.

FREQUENTLY ASKED QUESTIONS

Before reading the answers, think for yourself: **how would you answer them?**

1. But I've heard everyone is prone to one learning style (auditive, visual, reading/writing, kinesthetic), shouldn't we take that into account when designing teaching activities?
2. I feel I'm learning better when focusing on the topic for hours and studying it all day (called massed practice). Can it be different for different people?
3. What methods are best to teach different age groups and use in different settings (business meeting, volunteer training etc)?
4. It seems this way of approaching teaching takes much more time. Sometimes we are asked to get a specific topic across, which also requires actually giving quite a lot of info from our side (like explaining reuse policies or separate collection). How can we accommodate all this into the short time we are given?
5. Do images and visuals help people learn faster and remember longer the topics we are teaching?

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Learning styles is a very common learning myth. This means we can have our preferences on how we like to learn, but it doesn't mean we learn more effectively like this. The best summary of this topic is a [TED talk by Tesia Marshik](#).

2. I feel I'm learning better when focusing on the topic for hours and studying it all day (called massed practice). Can it be different for different people?

This is also a common learning illusion that we have. The brain and memory work more or less the same way for everybody, it's like the lungs function the same way for everybody. The information starts to feel familiar and clear, because it keeps circulating between our working memory and our short term memory. What we actually want is for this knowledge to stay in our long term memory also perhaps in critical moments in a few years from now, when we haven't used it for some time. This means that we need to practice forgetting and recalling it again. This means learning should also incorporate this pattern and it's better to learn in shorter periods of time, with breaks in between (called spaced practice), where we are doing other things, so that we can forget it for a while.

3. What methods are best to teach different age groups and to use in different settings (business meeting, volunteer training etc)?

We should not be focusing so much on methods as they can also distract us from the main purpose of our teaching. The main question would be, in which situation the learner thinks the deepest (with deep thinking we mean that new information will be connected to various previously known material and, when lucky, even organized meaningfully), is the most actively cognitively engaged to the material and discussion, and this may sometimes mean confusion and even a little frustration – in case the learner does not know that entertaining and passive listening is not optimum context for their learning. Thus, a simple question and answer session can deliver a better result than a session full of videos and images, if it's well connected to the session's goal. The main thing is to think about what is happening in the brains of the learners. It's about following these principles: activating learners' pre-knowledge, making their thinking visible to you, creating effort and allowing mistakes to happen, delaying your own expert opinion and giving it only after learners have struggled to find it themselves first. And these principles should be put to use in all different settings, regardless of the age or the background of the learners. If you need some more concrete guidance, you can check the *Trainer's checklist* of this handbook.

4. It seems this way of approaching teaching takes much more time. Sometimes we are asked to get a specific topic across, which also requires actually giving quite a lot of info from our side (like explaining reuse policies or separate collection). How can we accommodate all this into the short time we are given?

We cannot change the brain into learning more and faster than it does, this is just something that we need to accept. And it can be difficult to get this idea across to people who have hired us to give the training or workshop. We should still try to explain what is in reality doable in short sessions, if we indeed want people to learn, and give our best explanations for that. It could change our clients' minds :) Of course it is not always accepted and we are still asked to give lectures. In these cases we can at least create micro-discussions in the session, start with questions, leave little pauses for people to think, give them small tasks (which option is better: A or B? Why?) and so on.

5. Do images and visuals help people learn faster and remember the topics we are teaching for longer?

It is true that getting information from different senses (talk, text, visuals) can help learning – it allows us to link one and the same information unit in our memory with different stimuli. But images alone may not activate deeper (and often more abstract and complex) thinking; they are probably not enough on their own. Second, sometimes we want to use pictures that have great emotional load (which is often done in environmental communications) – shock, disgust, horror, fear etc. While it's true that they draw attention, negative images could also suppress people's need for autonomy (one of the basic psychological human needs), as they can create a sense of pressure, guilt and control, a sense of being pushed to do something.

But of course, they may help to enhance meaning, if creating empathy – but this impact, when activated solely through emotion, may be short-term. What we need is to activate people’s pre-knowledge and support constructing new knowledge, and help them find their own meaning in the topic. So the images need to be combined with activities that do that.

Ending questions for the reader to reflect upon:

- **What parts in this chapter were most confusing or difficult for you to understand? Why do you think it was so?**
- **How does it relate to your own learning and teaching experience?**
- **Have you taught differently than recommended in this chapter? How does it make you feel?**
- **What do you want to take with you from this chapter?**
- **If and what next steps do you want to take in your work regarding this topic?**
- **What do you want to know more about?**