SCIENCE OF LEARNING / OVERVIEW

# How to promote deep understanding in your classroom

the education hub

## Summary

*While we may intuitively understand the crucial role of understanding in learning, it is useful to unpack in more detail the building blocks of the learning process and consider how we can use this information to support the learning and development of higher-order thinking skills in our students, such as creativity and critical thinking.*

# Learning in the brain

The brain is composed of nerve cells, and their basic function is to communicate with each other by transmitting and receiving signals. Our knowledge base is represented in networks of neurons, and the ability to recall any given concept (a word, object, procedure) is based on a synchronous activity of a specific neuronal network in response to a certain cue.

The most important feature of neuronal networks is plasticity – the ability to constantly change and to create new connections and new patterns. This feature enables us to learn and remember. When we experience something new, our neurons respond in a certain pattern after which they may undergo consolidation to stabilise the newly activated pattern, and newly created connections. This process would potentially enable us to recall this piece of new information in the future.

### The factors that influence the quality of learning are:

- A new concept is always learned in association with already existing knowledge.
- The amount of existing knowledge and level to which it is interconnected influence the quality of learning (more interconnected knowledge leads to easier and faster learning)
- Connections between new and old are formed following a mutual activation – the new concept and the relevant existing knowledge are all active and connected during learning.
- The connections between the new concept and the prior knowledge are meaningful to the learner.

We will consider the possible classroom applications for each of these factors below.

# What is meaning?

Research shows that information is much better recalled if it was processed meaningfully during learning. A new concept is considered to have meaning once it enables the brain to respond; or, in other words, once the new concept is integrated with the existing representations in a way that supports an action or a decision.

For example, when a child learns the word 'shoe' – it becomes useful once an effective association is made to the already familiar object. Only then can she understand the sentence "put on your shoe", and respond to it. The new concept can now be used to execute an action.

At the basic level of learning we attach a concrete meaning to a meaningless concept (e.g. a word) – like the name of a person (Eli), an action (play) or an object (ball). The meaning relies on the ability to use the new concept to communicate effectively. The recurrent successful use of a word reinforces the associations within the network, and the concept becomes more robust. Creating meaning relies on concrete experiences.

At higher levels of learning, concepts with concrete meaning are used as examples for more abstract or more general concepts. For example, if we wish to teach what "equal" means we can say "If Eli has one ball and Sam has one ball, then they have an equal number of balls". We establish the meaning of the new concept "equal" on the basis of already known concepts ("ball", "Eli", "has", etc.). Later, we can go further up the pyramid and connect "equal" with more abstract concepts such as "equality" or "equity".

## Memorising versus understanding

When we memorise we are able to recite a certain fact like "4 x 3 = 12". A student who is able to do this would not demonstrate understanding of multiplication. But according to the formulation above, the student does know "four times three" at a basic level which would allow effective communication at a low level and in a very specific context (i.e. answering a question in a maths quiz). To create a higher level of understanding, we need to give more concrete examples (e.g. "Eli has three baskets, and there are four balls in each basket") and connect them explicitly ("so we can say Eli has three times four balls"). If we repeat this example and add many others, and then make sure the student is practising them repeatedly and effectively, we will establish an understanding of the concept "multiplication". As a higher-level concept, it will now be useful in various situations, and can serve as a basis for future learning. Every time multiplication is used, it is an opportunity to practise it and to receive positive feedback that helps to anchor it further in the brain. Eventually, the student will master the concept and will be able to use it effortlessly.

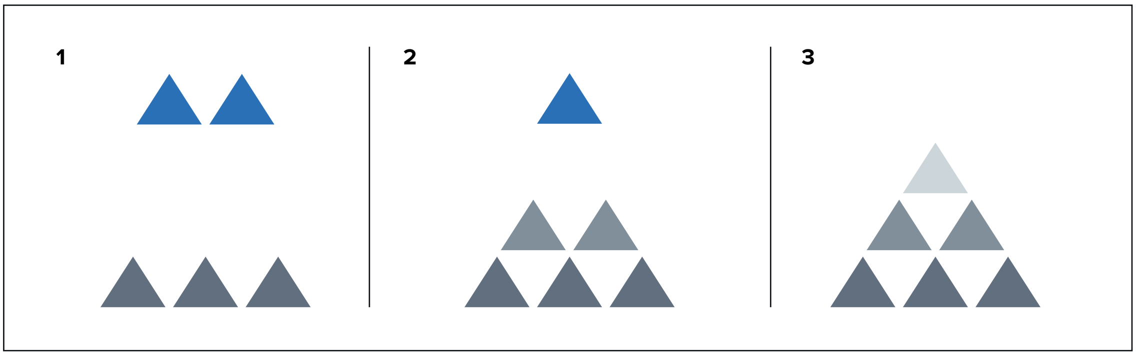
We can map the common terms "memorising" and "understanding" into lower and higher levels of understanding respectively. Understanding (on each level) is achieved on the basis of the available background knowledge and on the meaningful connections that were learned and practiced.

## Knowledge versus understanding?

It becomes clear that memorising and understanding are not opposites, but rather two components of the same thing. Knowledge is the collection of concepts represented in the brain, and understanding is the connections that they form, such that they are interrelated and dependent on each other. This view highlights two important features of our learning system:

- It is hierarchical: new must be built based on the previous.
- It is based on meaning: the glue that puts the pieces together is our ability to use the new in the context of the previous.

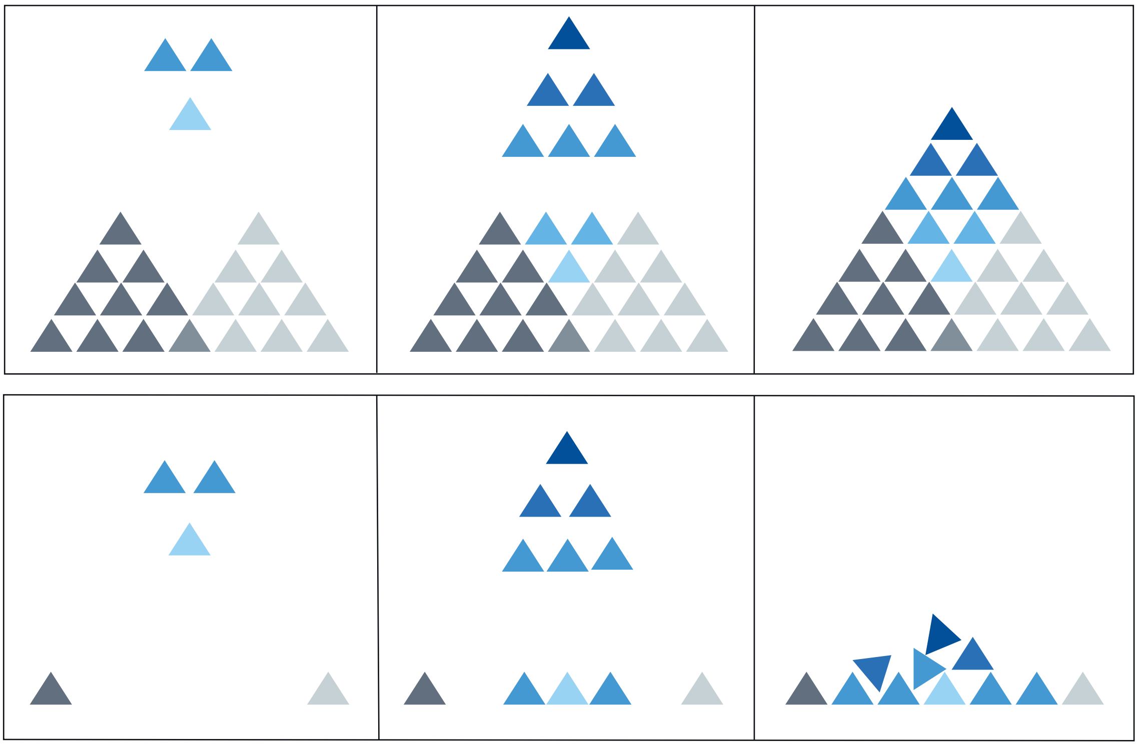
The learning process can be described as a pyramid – where the knowledge pieces are the bricks and the structure they form depends on understanding.  The final product is dependent on both:



As we learn more, we create more pyramids, and more opportunities for higher-order learning (where a whole pyramid becomes just a brick in a new one), and interdisciplinary learning (that is supported by several other pyramids):

**Higher-order learning is dependent on existing knowledge structures**



Understanding the nature of this hierarchical and interconnected structure directs our attention to two important issues:

- **Higher-order learning abilities are dependent on the solid structure of well-established knowledge.** Hence teaching wide and deep knowledge in meaningful ways is a crucial goal of education, and especially in the age of technology and readily available information. Knowledge must be carefully learned and be represented in the individual's brain in order to support higher-order skills. In other words, concepts in the brain cannot connect to concepts which reside only in external sources, thus learning knowledge and structuring it is essential for meaningful understanding.
- **Higher-order thinking skills, like critical thinking and creativity, are attained only on the basis of a solid body of knowledge in a specific domain.** There is no benefit in teaching critical thinking or creativity as a general "skill". Rather, we should build the relevant body of knowledge and then deliberately practise the way of thinking we wish to develop among the students.

## Applications in the classroom

As educators, at times we may aim our teaching at a certain level of complexity yet we feel that some of our students "still do not understand". Most likely, they lack either sufficient relevant background knowledge or the ability to connect it meaningfully to new material. It's not that students who did not demonstrate an understanding of concepts like "multiplication" or "photosynthesis" didn't understand anything at all. They may have understood it at a low level, which is only sufficient to perform a narrow range of tasks. For a concept to be retained in the long-term memory it is necessary to consolidate its meaning through ongoing practice and reinforcement.

# How to promote deep understanding

We aspire for our students to attain higher-level understanding, so that information will be accessible and useful in the future. The route to understanding includes three basic components: **new knowledge, prior knowledge** and **meaningful connection**:

## 1. The new concept needs to be explicit, distinct, and clear.

→ Present the new concept before learning to establish familiarity, if possible even more than once.
For example:

- Write it on the board as a preview for the lesson.
- Mention a concept in a context of future learning, or in a written future subject list.
- Give light homework assignments, targeted at establishing familiarity, not understanding.

→ Present the new concept explicitly, clearly and distinctly to ensure processing.

- Explain the concept explicitly in a direct instruction setting; repeat shortly after if possible.
- Give a straightforward explanation, rather than let students explore and discover (these inquiry-based activities are more appropriate at later stages).
- Present only one new concept at a time, so as not to overload working memory resources.

## 2. Relevant prior knowledge needs to be available and active.

→ Prior knowledge is the base of any learning pyramid, and is essential for future learning and higher-order skills.

- Teach a rigorous content-rich curriculum. These are not just useless facts, they are essential bricks for future pyramids. Ample evidence exists to support this, explained and demonstrated here, in Willingham's book chapter2 (see below), and specifically about reading comprehension here.

→ If prior knowledge is not available, there is no other way but to teach it.

- Time is better spent on teaching the basics than trying to teach new content without it.

→ The relevant information should be active at the time of learning

- Teachers reviewing relevant material often creates the illusion of active prior knowledge. It is tempting to assume that students intuitively relate new concepts to their background knowledge, but this is not always the case, especially when they are novices.
- **A short questionnaire on the required knowledge** would serve as effective retrieval practice, as preparation for the learning, and possible formative assessment for the teacher to understand whether students have retained relevant information.

### 3. Create explicit and meaningful connections between prior knowledge and a new concept.

→ The connections between the new and the existing should be explicit.

- Following explanation, a teacher may use the elaborative interrogation method prompting the students to explicitly and specifically explain the learned facts using questions like “why” and “how”.

→ Connections are understood on the basis of already familiar connections: use familiar and well-grounded concrete examples that represent the type of connections we are teaching. Examples:

- The pyramid illustrations above are a concrete example of the relations between abstract concepts knowledge and understanding.
- Real objects (e.g. fingers) are examples for number concepts.
- Matrices of real objects are examples for the multiplication concept.
- Visual or physical models help explain scientific concepts like DNA, forces, or currents.

Professor Daniel Willingham says “understanding is remembering in disguise”. In chapter 4 of his book he supplies many more examples and clear explanations.

## Implications for students with different backgrounds

It is clear that the background knowledge each student has gained is the basis of their individual learning pyramids. This factor greatly influences how easy new leaning will be for them, and how deep they can go. If the previous knowledge was well established, it will be more easily utilised by the students, even without help from the teacher. When the background knowledge is shallow and not practised, it probably won’t be utilised effectively and independently. It means that different students can be characterised as “quick learners” or “smart” and even “creative” just because they have gained more knowledge and it is better established in their minds. As students learn more, their ability to assimilate new knowledge grows – just like with pyramids, the wider the base, the higher you can reach.

As teachers we can take steps to support students’ learning by focusing on allocating their cognitive resources effectively. It is important to make sure that student gain new knowledge and understand it, and then practise it to reach mastery. It is fashionable to talk about 21st century essential skills and sometimes even to contrast them to skills that were required in the past. Hopefully, the information presented here makes it clear that knowledge, understanding and deliberate practice are still the basis for all knowledge and skill development. A teacher’s work is essential to making sure each child’s knowledge base is as solid as possible, so that they can freely explore opportunities that we cannot even imagine.

# References

The one resource that is recommended to learn more is the book:

Willingham, D. T. (2009). *Why don't students like school?: A cognitive scientist answers questions about how the mind works and what it means for the classroom*. John Wiley & Sons.

It is based on research and written especially for teachers, includes clear explanation, compelling examples and demonstrations (some of them can be shared with students as well), and classroom applications. Specifically relevant are the following chapters:

Chapter 2: *"Factual knowledge must precede skill"* on the importance of knowledge as building blocks.

Chapter 4: *"We understand new things in the context of things we already know, and most of what we know is concrete".* On the importance of familiar concrete examples, deep knowledge and transfer.

Other useful resources include:

McLeod, S. A. (2007). Levels of processing. Retrieved from www.simplypsychology.org/levelsofprocessing.html

Willingham, D. T. (2007). Critical thinking. *American Educator*, 31(3), 8-19. https://www.aft.org/sites/default/files/periodicals/Crit_Thinking.pdf

Willingham, D. T. (2006). How knowledge helps: It speeds and strengthens reading comprehension, learning-and thinking. *American Educator*, 30(1), 30.

https://www.aft.org/periodical/american-educator/spring-2006/how-knowledge-helps

Research Bites – Elaborative Interrogation via Durrington Research School (UK) blog https://durrington.researchschool.org.uk/2018/01/16/research-bites-elaborative-interrogation/

The Learning Scientists Podcast: Episode 10 - Concrete Examples

http://www.learningscientists.org/learning-scientists-podcast/2018/1/3/episode-10-concrete-examples?rq=concrete%20examples

Hirsch, E. D. (2003). Reading comprehension requires knowledge—of words and the world. American Educator, 27(1), 10-13. https://www.aft.org/sites/default/files/periodicals/Hirsch.pdf

No "far transfer" – chess, memory training and music just make you better at chess, memory training and music. By Alex Fradera via The British Psychology Society, Research Digest. https://digest.bps.org.uk/2017/11/24/no-far-transfer-chess-memory-training-and-music-just-make-you-better-at-chess-memory-training-and-music/