Christodoulou, D. (2020) *Teachers versus Tech,* Oxford: OUP

It is easy to laugh cynically at new inventions. It is equally easy to fall gullibly for them. Sometimes, new inventions are seen as downright dangerous. Deciding to be pro or anti-technology is not helpful. We need to move away from this dichotomy.

1. The Science of Learning

We need to reconnect education and technology with the research underpinning them.
Perhaps the most relevant research in the science of learning is the distinction between long-term memory and working memory. Working memory is the small amount of information that can be held in mind and used in the execution of cognitive tasks. You can test how small the working memory is by giving yourself five seconds to memorise this 18-letter string.

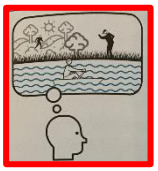
SBB CNH SGM TRA FIT VFA

Most people will struggle to memorise more than seven letters.
Recent research suggests that most people can only keep about four new items in their working memory. In contrast to working memory, long-term memory is vast. Another quick test can reveal this. Now try to memorise this string of 18 letters.

S BBC NHS GMT RAF ITV FA

This is much easier, even though the letters are exactly the same and in the same order. The difference is we don't have to rely solely on the working memory, which is easily overwhelmed. Here, we have familiar acronyms, so we don't have to memorise 18 individual items. Instead, we use the information in the long-term memory to chunk the 18 letters.

Long-term memory, therefore, consists of well-organised knowledge structures that allow us to make sense of information. If we encounter the word money, for example, we might think about coins, credit cards and payslips. If we read the word 'bank' straight after, we're likely to think about finance.



Yet if we'd read the word 'bank' the sentence after reading the word 'river', we'd have called up a different knowledge structure from our long-term memory.

Let's now look at how we build knowledge. We might think the best way to do this would be to allow pupils to work independently. We might think that pupils should participate in enquiry-based or project-based learning. Here, we offer minimal guidance. However, this method has significant problems.

Reducing guidance and structure makes tasks more complex. Complex tasks will often overwhelm the working memory. The problem here is confusing the end goal of learning with the method of learning. If we want pupils to solve complex problems we think the best way is to always solve complex problems. But to solve problems we need a lot of knowledge first.

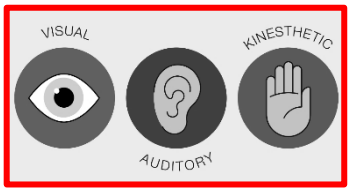
Research cited by Christodoulou suggests that direct instruction, which offers structure and guidance, is much better than discovery-based learning. Direct instruction involves questions and answers, review and repetition, modelling and practice. We can pick up some skills in an unstructured way, but it isn't easy. We haven't evolved to decipher the mysteries of the apostrophe or sentence structure through unstructured exploration.

This helps to explain why online search and digital reference sources are not the panacea they are often assumed to be. Looking something up on the Internet takes up valuable space in working memory. Reference sources help people who already know a lot of the words, but they are not so effective at learning new words.

1. The science of learning: summary

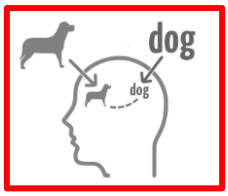
Working memories are limited	We need knowledge in long-term memory. Direct instruction is probably most effective to gain this knowledge
Long-term memory allows us to make sense of information	

2. Can technology help personalise learning?



Students have many things in common, but they also have different learning needs. Each student brings different levels of background knowledge and vocabulary to the classroom. Educational technology provides the opportunity for personalised learning. However, it's very difficult to define what personalisation means. In a survey of 67 schools, researchers found 67 different interpretations of personalisation. Research into one type of personalisation – that of different learning styles - has now been thoroughly debunked.

When we are learning, what matters most is not our preferred or best learning style, but the best learning style for the content. If you want students to learn the locations of countries in Africa, a visual presentation is always best, for all students. It would be unhelpful if you gave a map for visual learners and read aloud a list of countries for the 'auditory learners'.



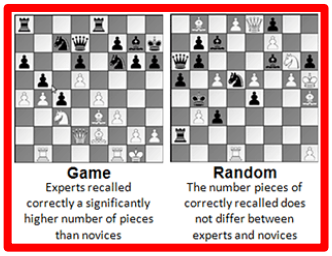
Plenty of research shows the value of combining words and images together. This is also known as dual coding. The combination of words and images is easier to understand – for everyone, not just for learners with a particular learning style. We shouldn't deny resources to students because it is not their style. Rather than thinking of the student, we should think of the content and which presentation is best for that content.

'Self-paced' student environments appear to fare little better. The literature appears to suggest that often learners are not well-equipped to make good decisions about their learning. Our emotions and opinions are often not a reliable guide to learning. We may feel that repeating an easy task over and over again is boring. But sometimes 'overlearning' can be valuable because it builds fluency and automaticity.

We can also struggle when learning something for the first time and think we should stop. But 'desirable difficulties' are a part of learning and judging what makes the difficulty desirable or undesirable is not easy. Furthermore, students' most popular strategy for revision is to reread their notes, but this is ineffective: self-quizzing or 'retrieval practice' is far better. The way to improve judgement about competence, argues Christodoulou, is to improve your competence. So, rather than expecting students to make good learning choices when they are novices, we should give them guidance and knowledge so they eventually can make good learning choices themselves.

There are adaptive systems available. These systems use algorithms that help pupils to relearn content they have forgotten or to overcome misconceptions. However, adaptive systems can be expensive and time-consuming to develop. Some are available for mathematics and reading, for example, but not for other subjects. Ed tech can't help us here across the full curriculum– but adaptive systems might be worth exploring in the future.

3. Why can't we just look it up?



Some people have argued that because technology has made accessing knowledge cheaper and easier, schools should place less emphasis on knowledge and memorisation. This is wrong. This is because, as we've seen, we need facts to think. Knowledge is an extremely powerful part of human cognition, and one that is integrated with all of our mental processes.

In a famous study of chess players, researchers found that grandmaster chess players were able to recall the 25 pieces on the board after the game had been covered up. Less expert players could only recall 8-12 pieces. However, when the pieces were random, both novices and masters scored poorly. When recalling all 25 pieces, the chess players weren't reasoning, they were recalling. So we need subject-specific information in long-term memory to become expert. There aren't general strategies we can learn to make us expert across different subjects.

Mrs Morrow stimulated the soup.

Some people have suggested that an online dictionary can suffice for learning. But, in some research with 8-year olds, they found that when giving pupils just a target word and a paper dictionary, they got some very strange results. The child who looked up stimulate found 'stir up' among the definitions. The child who looked up erode found 'eat out' and 'eat away' and thought 'our family eats out a lot'. So she substituted erode for eat out.

Our family erodes a lot.

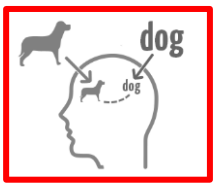
Looking up new words is a 'high level cognitive task'. It easily overwhelms limited working memory capacity. Students can end up with no idea what the word means or with the wrong idea. However, if you know something about the topic you are researching, it becomes easier to construct a useful search. It is also much easier to interpret the information you find. The paradox is that reference sources are most useful to people who know something about the topic they are looking up.

Adults can forget this. They think of the mechanics of constructing a search. They forget about the specific content knowledge needed to know what to search for and how to interpret the results.This is often referred to as 'expertise-induced blindness'.

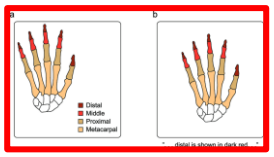
There is one other reason why we can't just 'look it up'. Being able to spot unreliable information is not just about generic critical thinking skills. The ability to spot dodgy information is tied up with specific content knowledge
The Pacific Northwest Tree Octopus is a famous hoax website created in the 1990s. Adults can easily see that the website is a hoax simply because they know about octopuses. They know octopuses are not found in trees.

However, many students believed that the website was reliable. There was an author clearly stated on each page, and there were links to other websites. That wasn't enough, however, for the children to work out that it was a hoax. In summary, you don't get better at learning independently by learning independently. Quite often, we can't easily just look it up.

Technology *can* help in two more promising ways, however. First, we can use technology to create coherent and memorable content. Second, we can use technology to enhance memorisation, not replace it. The work of Richard Mayer can help us to think about how technology can help create memorable content. Mayer's multimedia principle suggests that presenting words and images together can enhance learning. It also allows us to build more sophisticated mental representations of what we are trying to learn. When we see words and images together, we work to connect the two, a form of active mental processing that helps build understanding.



Mayer didn't stop there. He suggested that the way we combine text and images is important. The split attention effect shows that closely integrating text and images leads to better learning, as in (a) rather than providing them separately, as in (b).



A final principle was the redundancy effect. If I were to present you with the same text that I was reading out, to ensure you were paying attention, would this help? The research suggests no. If learners have to deal with the same written and spoken words at once, they spend precious working memory resources co-ordinating the written and spoken words. This leaves less working memory available for learning.

Mayer's principles don't depend upon certain technologies. However, many of the principles do lend themselves to newer technology. It's easy to combine images, texts and cues together in a digital presentation and easy to reveal information in progressive stages too. However ,it's also easy to misuse digital media. Modern technology makes it easy for teachers to read out words on a slide, violating the redundancy principle. Some images are used for decoration, which can confuse and distract learners.

Not all content is created equal. We need to create optimum content for students, not rely on them stumbling on them online by chance.

In summary, instead of expecting technology to eliminate the need to build memories, we should instead use technology to make it easier for us to build memories. And we need to build memories to be able to make sense of the world around us.

[End of Part 1]