Memory in the classroom

David Crabtree ***offers some thoughts for practitioners***

Memory, cognition and learning

Whatever the subject that you are teaching and whatever the age of your students, knowing about memory, cognition and learning is very important for successful classroom practice. Memory is required to learn, yet learning is more than simply memorising. In the classroom, it is the teacher who is responsible for the good cognition of the class. Cognition relates to thinking and the processes of the brain. Learning is demonstrated when our learners tap into that knowledge and information to think and work out their own responses.

At this point, it is quite useful to think about what model or idea you may have when thinking about your teaching and your students' learning. Is it a straightforward input model? (Figure 1)

Stage model of memory

While several different models of memory have been proposed, the stage model of memory is often used to explain the basic structure and function of memory. Initially proposed in 1968 by Atkinson and Shiffrin, this theory outlines three separate stages of memory: sensory memory, short-term memory, and long-term memory.

In this model, Atkinson and Shiffrin describe memory in terms of information flowing through a system. Information is detected by the sense organs and enters the sensory memory. If attended to, this information enters the short-term memory. Information from the short-term memory is then transferred to the long-term memory.

The key thing about this model is the notion of 'if attended to'. The implication of this for classroom practice has been the notion that learners need to 'attend to' in order to learn. This model, and this attitudinal assumption has tended to dominate much thought about classroom practice.

Recent research on the way that the brain works grants us access to processes previously invisible. Using evidence from brain scans and such like, there is now substantial evidence that there is an important executive functioning between short-term

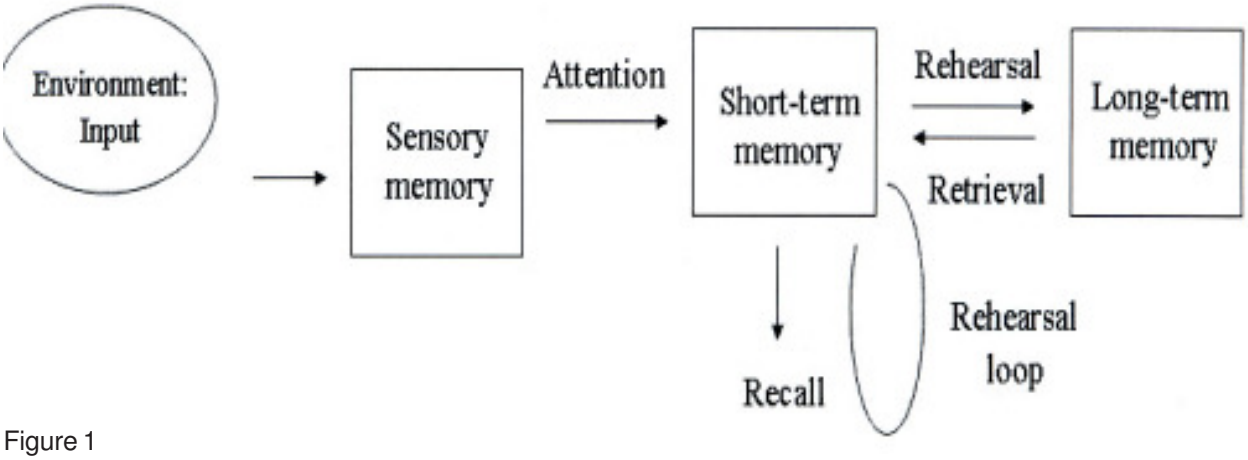

Figure 1

memory and long-term memory. This part of the memory process has been shown to be a critical factor in classroom learning. This part of the cognitive process is critical for teacher management of learning.

Rather than retain everything, the brain constantly sheds information (Crabtree, D. 2013. Belgrade: British Council English Language website). This shedding of information has been described by Susan E. Gathercole at the University of Cambridge as 'catastrophic loss'. Once something has been shed from this part of the memory process, it is lost forever. This catastrophic loss happens within the 'memory preparation area'.

Only things stored in long-term memory are retained. For this storage to happen, knowledge and information must pass through short-term memory and be prepared prior to being placed into long-term memory. The preparatory stage for long-term memory uses a form of memory additional to the model of learning proposed by Atkinson and Shiffrin. The additional element is working memory.

It is this part of the memory process that has been shown to be a critical factor for successful classroom learning. This is because working memory prepares things for storage into long-term memory. There is another function for working memory that is critical for classroom learning; it is also required for any activity which requires us to both hold onto information and process information.

No matter what the subject or topic, classroom learning relies upon learners holding onto information while they process information. So here is a more developed model.

How knowledge and information are retained in memory

Stage 1. Sensory Memory
Sensory information from the environment (eg your teaching) is transferred to the brain and stored for a very brief period of time, generally for no longer than a half-second for visual information and three or four seconds for auditory information. Some of this information passes into the next stage – short-term memory.

Stage 2. Short-term memory
Short-term memory, also known as active memory, is the information we are currently aware of or thinking about. Most of the information stored in active memory (eg your teaching) will be kept for approximately 20 to 30 seconds. The majority of short-term memories, once they have been 'used', are quickly forgotten. The forgetting of a short-term memory means that a nerve impulse has ceased being transmitted through a particular neural network in the brain. In general, unless an impulse is reactivated (eg by something in your teaching), it stops flowing through a network after just a few seconds.

Stage 3. Working Memory
Working memory acts as a kind of holding area for temporary recall of the information which is being processed at any point in time. This is the ability to remember and process information at the same time. Note that much of what happens in any classroom and in any lesson requires the learner to remember and process information at the same time. A simple example of this is to remember an instruction or instructions whilst also carrying them out.It also serves as a preparation zone for transmission and storage into long term memory. It holds a small amount of information (typically around seven items or even less) in mind in an active, readily available state for a short period of time (typically from 10 to 15 seconds, or sometimes up to a minute). Consequently, if you require your learners to remember something to be recalled at a later date or even stage in the lesson, it is in this holding area of memory that you create the opportunity for storage.

Because working memory is an extension of short-term memory and therefore relies upon nerve impulses, it also shuts down unless constantly reactivated.

Stage 4. Long-term memory
Long-term memory refers to the continuing storage of information. This information is largely outside of our awareness, but can be called into working memory to be used when needed. Some of the information is fairly easy to recall, while other memories are much more difficult to access. Retention in long-term memory requires the formation of a new synapse in a neural pathway. This creates a physical restructuring in the brain. Once created, it is not easily lost and is strengthened the more it is linked to other synapses and the more the new neural link is activated. In such a way, long term memory is physical and far more permanent. Neurologists refer to the plasticity of the brain, and studies have shown how the brain can grow in relation to greater knowledge or can repair itself by developing new neural connections to overcome loss of function following damage.

No matter what the subject

The important thing for teachers to note is that, no matter what the subject or topic, classroom learning

relies upon learners holding on to information whilst they process information. The part of cognition critical for this is working memory. For the majority of the population, working memory is a time limited memory and once gone is subject to catastrophic loss. It is lost forever. It is this part of cognition, therefore, that requires good classroom management.

Learning is demonstrated by tapping into knowledge and information to think and work things out

The ability to access and retrieve information from long-term memory allows us to make decisions, interact with others and solve problems. But how is information organised in memory? The specific way information is organised in long-term memory is not well understood, but researchers do know that these memories are arranged in groups, and for the brain to retain new information requires this to be linked to existing information already retained by the brain.

Clustering is used to organise related information into groups. Information that is categorised becomes easier to remember and recall. For example, consider the following group of words: desk, apple, bookshelf, red, plum, table, green, pineapple, purple, chair, peach, yellow. Spend a few seconds reading them, then look away and try to recall and list these words. How did you group the words when you listed them? Most people will list using three different categories: colour, furniture and fruit.

Such clusters relate to neural pathways of connecting synapses. When you learn something, it is actually these synapses whose efficiency increases, thus facilitating the passage of nerve impulses along a particular circuit. For example, when you are exposed to a new word, you have to make new connections among certain neurons in your brain to deal with it: some neurons in your visual cortex to recognise the spelling, others in your auditory cortex to hear the pronunciation, and still others in the associative regions of the cortex to relate the words to your existing knowledge. In such a way, new knowledge is combined and linked to existing knowledge.

All memories (of events, words, images, emotions etc) thus correspond to the particular activity of certain networks of neurons in your brain that have strengthened connections with one another. As teachers, our job is to use this knowledge to increase our pupils' learning.

What is the consequence of all this for educators? Working memory capacity differs across the human population. This difference is natural. It is an aspect of human diversity and one reason for our survival as a species. However, in classrooms around the world as they are currently organised working memory capacity bestows an advantage for some learners and a disadvantage to others. Learners have different capacities of working memory. Some learners can hold and store relatively sizeable amounts of information in a working memory and they can do this for a longer period of time than others. Some learners have a smaller capacity because their nerve impulses shut down sooner. This is biologically determined and learners have no control over this aspect of cognition.

Working memory capacity is not connected to intelligence or ability, and some of the brightest and most able learners will have less working memory capacity than others. 'Forgetful' learners, 'off-task' learners and 'easily distracted' learners tend not to be best thought of by educators, Once the short-term memory nerve impulse within working memory has shut down it is lost and gone forever, unless reactivated. Yet many of these will be potentially amongst our most able. For these learners' potential to be realised requires a style of teaching and classroom management in which working memory is supported.

There is now substantial evidence about the importance of working memory in learning, especially during the childhood years. Studies by Susan Gathercole and Tracey Alloway have investigated the relation between children's working memory capacity and their learning achievements in areas such as literacy, language and mathematics, and produced extensive evidence that working memory is linked to key learning outcomes in literacy and numeracy (Alloway, T. P. and Alloway, R. G.). In fact, a child's working memory at five years old is a better predictor of academic success in the current way that classroom learning is organised than IQ (Gathercole and Alloway).

Much so-called poor classroom behaviour can be attributed to shut down of the nerve impulses in short-term memory. Also, inefficient transfer to long-term memory is caused by the premature closing down of 'packaging' into a long-term memory. The solution lies with the memory process being supported, activated and reactivated. There are styles of teaching which do this.

One way to support working memory involves multi-sensory instruction. This is because more neural pathways are opened and more nerve impulses come into play, thereby opening a 'super-highway into learning' (Crabtree, D. 2013. Belgrade: British Council English Language website). Another approach is to make good use of scaffolding approaches. These support the learner to stay on task and focus on the learning outcome. Scaffolding reduces the possibilities for shut-down. Equally,

ensuring that there is a clear link between what is being taught and what the learner already knows provides a hook for neural pathway connections and links the lesson into an existing cluster already established in long-term memory. By making this link and reinforcing the hook, the pupil remembers and the memory is more likely to be available for retrieval when required.

Is there anything in all of this for post-16 educators?

First, working memory is critical for all learners, and very large numbers of post-16 learners will share one common denominator: smaller working memory. This is because working memory is a critical determiner of achievement for school-based learning. Learners who come into post-16 education and training with a low school achievement profile will do so because their working memory was a disadvantage in the school classroom. By and large, they will have good intellectual ability but have had a poor school experience.

Secondly, working memory is to a certain extent genetically programmed. Academic success has been largely the prerogative of those with average and above average working memory facility. The vast majority of educators and education decision-makers will have average and above average short-term memory. If we, as educators, continue to bestow advantage on those with average and good short-term memory by maintaining classroom practices that support this group to the disadvantage of others, we continue this process of discrimination and the unfair distribution of achievement.

Thirdly, those with smaller amounts of working memory tend also to be excellent strategic thinkers. They have the ability to quickly find solutions to complex problems and focus on what is critically important. Their cognitive skills remain unrecognised unless we support them to realise their potential.

Finally, much of post-16 and adult education is about real, tangible things. Learners with small working memory relative to that of the overall population find this kind of learning more to their liking.

Conclusion

As teachers, we demonstrate our knowledge about memory, cognition and learning in the classroom by: being aware of differences in the working memory capacity of our learners; responding to these differences by managing working memory using a range of teaching methodologies; creating a clear pathway for learning retention into long-term memory by using knowledge of memory, cognition and learning in our planning and delivery.

References

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