**Cognitive load theory (CLT)**

The Australian educational psychologist John Sweller developed the cognitive load theory (CLT) (Sweller, 1994). This theory focuses on how much information can be held and processed in the working memory of the brain at any one time, in order to perform a task (Tharby A 2020; Reif, 2010). It is currently experiencing a re-emergence in education with Dylan Wiliam entered into the debate, endorsing the theory via a tweet, January, 2017; ‘*I’ve come to the conclusion Sweller’s “Cognitive Load Theory” is the single most important thing for teachers to know’* Creaby C, 2020). CLT is about with the capacity of the working memory (WM) to process information (Sweller, 1998). CLT requires some understand of two aspects of the workings of the brain, specifically working memory (WM) and long-term memory (LTM).

The working memory has limited capacity it can become overloaded. When it is overloaded it struggles to process the new information that it is receiving or make links to the existing schemata in the long-term memory (Kirschner et al, 2006; Shibli 2020; Pope, D., 2020). To reduce the chances of cognitive overload it has been suggested that learning should be divided into small chunks with activities that do not draw on too much memory capacity. In this way learners have time to process the new learning and simultaneously link it to existing learning (schema).

However, before entering long-term memory and developing schemata, information must first be processed by the working memory. The working memory simultaneously links the new knowledge to existing schema in the long-term memory which make the processing of this new knowledge more efficient (Pope, D., 2020 & Shibli 2020). When learners acquire the new knowledge and it becomes integrated into the long-term memory it allows them to spend less time processing content, freeing up the working memory (Kirschner, 2002; Paas et al, 2003). The more information in the LTM the less the demand on the WM and the more capacity it has (Shibli 2020).

The long-term memory has infinite capacity. Long-term memory (LTM) consists of a range of schema (information, knowledge and meaning which are all linked together into topic eg about a flower) (Pope, D., 2020). Learning is about adding to and editing these schemata in the long-term memory through acquiring new knowledge and connecting with other schema. Experts learners possess far more detailed and complex schemata than novice learners.

There are three types of cognitive load (Pope, D., 2020; Chandler and Sweller, 1991; Paas et al., 2003). Together, **intrinsic load**, **extraneous load** and **germane load** make up the capacity of the working memory.

1. **Intrinsic load**

This is related to the difficulty and complexity of the subject matter being learned and is impacted by prior knowledge (what pupils already know). Tharby A (2020) provides the following examples; *“2 + 2 + 4 has less intrinsic load than 93 x 543, while understanding the workings of the human respiratory system has more intrinsic load than knowing where the lungs are situated in a human body.”*

1. **Extrinsic load**

The way in which the teacher has designed the learning sequences and teaching activities can also add to the cognitive load. As this is an external factor, which is arguably not necessary it is called **extraneous cognitive load**. This acts as barrier to integrating the new knowledge from the working memory into the long-term memory. This can interfere with the development of schemata and long-term memories and learning. As teachers we can reduce extraneous cognitive load by selecting appropriate explanations, instruction, and presentations to enhance the learning (Pope, D., 2020; Chandler and Sweller, 1991; Paas et al., 2003; Tharby A 2020).

1. **Germane load**

This can be described as a positive and productive load on the working memory as it contributes to the formation of helpful thinking and useful processing in the working memory. This leads to real learning and the formation and development of long term memories and learning (Pope, D., 2020 ; Tharby A , 2020). Strategies which teachers can use to optimise this may include; careful sequencing, use of modelling; scaffolding, prompting, dual coding etc). More recently Sweller (2019) suggested that germane load, rather than adding to cognitive load, in fact re-distributes the resources of the working memory from non-relevant activities to learning relevant ones.

**Implications for teachers**

The key principles of CLT need to be understood so that teachers can choose the best tool to reduce cognitive load and enhance germane load thus integrating the learning into the long-term memory. For example, teachers need to identify the key concepts to be taught in a subject and the best sequence in which they are presented. This will optimise the learners’ acquisition of schemata. This requires teachers to have a thorough understanding of the concepts within a subject as well as appropriate pedagogical knowledge to teach it effectively (Shulman, 1986). By starting with an assessment of prior knowledge, teachers can identify starting points in the new learning as well as gaps and misconceptions. Teachers will have to consistently adjust and respond to the children’s feedback to enable them to present the materials in an appropriate way to reduce cognitive load and enhance learning (Pope, D., 2020).

Taylor (2020) defines learning as a change in long term memory and this is supported by

Sweller et al (2011) who suggest that nothing has been learned if nothing in the long-term memory has been altered. It would seem important therefore that as teachers we employ strategies that help pupils make connections in learning so that new knowledge can be integrated into the long-term memory. So careful and thoughtful selection of pedagogy and resources is important eg careful sequencing, use of modelling; scaffolding, prompting, dual coding, retrieval practice vocabulary etc. If new material can be presented in such a way then it can reduce extraneous load and enhance germane load, this will free up space in the working memory to process and integrate the new information.

**Pope D 2020 identifies some practices to support CPD in CLT for novice teachers:**

* Create shared knowledge maps with colleagues of key concepts/ideas underpinning units of work across the curriculum.
* Focus attention on logical sequencing and highlight connections within, and between, subject topics.
* Regular revisiting during planning and preparation helps to develop mental models of the subject matter.
* Build ‘case’ knowledge through shared deconstruction and analysis of teaching and learning episodes.
* Teacher mentors make explicit the teacher’s decision-making processes, drawing especially on Pedagogical content Knowledge.
* Teacher mentors engage in co-planning and co-teaching with novice teachers to reduce their cognitive overload through carefully defined and managed foci.
* Use collaborative practitioner enquiry (e.g. the Lesson Study approach) to plan, implement and evaluate targeted interventions, expanding pedagogical discussions in the process.

**Slideshow presentations** (Tharby A , 2020)

A good slideshow presentation should:

* remain mindful of the intrinsic load of the task
* reduce extraneous load
* increase germane load.

1. **Less is more.** Reduce the amount of text and diagrams to as few as necessary, but no fewer. This will ensure that you do not overload your students’ limited working memory capacity.
2. **Ensure that labels** are integrated into diagrams so students can look at text and images simultaneously. This avoids the ‘split-attention effect’, when learners have to mentally integrate information by holding one thing in working memory while they search for another (Chandler and Sweller, 1992).
3. **Avoid reading out text** that is already written on the slide because it overloads working memory because students cannot process two types of language input simultaneously.
4. **Remove distracting or superfluous images.** Only use those that directly support learning, because unnecessary images create extraneous cognitive load.
5. **Use images to support complex and conceptual ideas**. The dual coding theory
6. **If you intend to explain an image**, it is best not to include written text at the same time (especially when you intend to be brief). Again, this can create extraneous load.
7. **Never expect students to read something** from the board while you are talking at the same time! It is not possible to split attention between both.
8. **Reveal processes stage by stage on the same slide**, rather than on consecutive slides. This way, students have a prompt to remind them of earlier stages and do not have to juggle too much information in working memory.
9. **Remember that spoken words and slides are fleeting** and transient and that your students’ innate cognitive architecture means that they will be unable to hold on to them all at once. Slide-show handouts and shortened ‘bursts’ of teaching can reduce this problem

**Caution**

*“Schools and teachers across the country are using concepts like cognitive load theory. This is a great thing, but does have some obvious dangers. Sound scientific ideas can become mutated and turned into new fads. And the last thing we need in education is the new ‘learning styles’* “(Muijs D, 2020 ). Pope, D., 2020 urges teachers not to rely on formulaic responses to CLT though tightly prescribed teaching methods. It is more than reducing clutter on presentation slides or ‘chunking’ and simplifying instructions. Teachers should use the understanding of the pupils in their classes and their own teacher expertise. The cognitive load theory needs to be balanced by the ‘expertise reversal effect’ which shows that expert learners may need a more enquiry-based approach to the learning rather than the explicit chunking approach that novices need (Kalyuga, 2007).

Expert teachers have a deep understanding of the challenges they face in pupils’ learning whereas novice teachers focus more on structure (Pope, D., 2020). Expert teachers have accessible and orderly schemata about teaching and learning and appear to make automatic choices in the selected pedagogy, strategy, resource or intervention. Moors and De Houwer (2006) in Pope D, (2020) note that expert teaches understand each situation well and know what cue and responses from pupils are pertinent to the learning and which are irrelevant. Their assimilation of the cues, information and subsequent responses seem automatic and effortless. As teacher expertise is embedded in schemata in their long-term memories there is a lower cognitive load on these staff. Conversely with novice teachers there will be a higher cognitive load as they are processing both the subject knowledge and pedagogical knowledge necessary to optimise the learning of the pupils (Pope D, 2020). Extraneous load may also be added through the demands of the classroom context including performativity, evaluation anxiety etc (Ball, 2013). Feldon (2007) describes that novice teachers frequently describe themselves as ‘feeling overwhelmed’ and so select strategies that may provide short term relief. Pope D, (2020) described a range of attitudes, practices and influences some novice teachers employed to get by *“eg hastily retrieved research prior to teaching and uncritical dependence on commercial schemes and resources left them relying on simplistic or incomplete schemata to inform their practice.”* To help novice teachers develop there is a need to make explicit to novices, what is implicit to experts.

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