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As/0. Written Debate: Final Submission

Chosen debate question (delete as appropriate):

How useful is cognitive science for everyday classroom practice?

Final response (1150 - 1350 words)

Over the last ten years there has been an explosion of cognitive science understanding in schools. In 2012, Barak Rosenshine drew together the research underpinning how children learn and shaped them into practical strategies teachers could apply in their classrooms (Rosenshine, 2012). As a result, Rosenshine's *Principles of Instruction* have become the bedrock of many schools' teaching and learning outlooks, and these principles essentially, and potentially, make cognitive science useful for everyday classroom practice.

Understanding the journey to these important principles begins with theories from cognitive psychology: John Sweller stated that 'there are two critical learning mechanisms: schema acquisition and the transfer of learned procedures from controlled to automatic processing' (Sweller, 1994). Sweller determined in this paper the cognitive architecture required for deep learning to take place, and cognitive load theory developed from here. After 1994, John Sweller's theories were then ripe for research into practical applications. Sweller's work led Dylan Wiliam to Tweet: 'I've come to the conclusion Sweller's Cognitive Load Theory is the single most important thing for teachers to know' (Wiliam, 2017), underlining the importance of cognitive science.

Language has since evolved, and we now employ terminology such as 'working memory' and 'long-term memory' when discussing cognitive architecture and learning. It is now routinely accepted that the working memory, where we process new information, is finite, whereas the long-term memory is of infinite capacity. As Sweller found, for deep learning to take place, we need to build schema and layer new knowledge on foundational knowledge (Sweller, 1994). Daniel Wilingham, another cognitive scientist, considers the interaction between working and long-term memory and writes, 'Memory is the residue of thought' (Willingham, 2009). Willingham proposed a model of learning where we deeply learn new skills and knowledge by retrieving them, multiple times, from the long-term memory to the working memory. Furthermore, we need to build schema in our memories where we connect ideas and learning, thus taking us from novices to experts. New learning is very hard to achieve with weak schema and thinking about previous learning is therefore essential (Willingham, 2009).

Following John Sweller's work, the processes of learning were emerging, and these theories could be tested in university lab-based settings. Multiple re-tests of material were compared to just re-reading/studying texts before a final summative test (Roediger, 2006). This study found that 'testing is a powerful means of improving learning, not just assessing it', thus confirming the memory models of Williingham and Sweller. The results of these studies on memory and learning were reproducible in classroom settings, as shown by Pooja Arjawal's meta-analyses of 2000 research articles (Pooja Arjawal, 2021). 57% of these studies showed that retrieval practice had a medium or large impact on learning

(Pooja Arjawal, 2021). Many other studies support the theories that material can be embedded into the long-term memory by revisiting it through low stakes testing, and thus Rosenshine's Principles as a practical way of how we could translate this research into the classroom setting were able to emerge. Cognitive load theory also shaped how the new material should be presented: by chunking, modelling, and introducing new material in small steps, which are all based on the working memory being finite and transference to the long-term memory being critical for 'learning'.

Compelling evidence from classroom settings is therefore in plain sight. But what are the potential limitations to the applications of cognitive science in the classroom, and is there any counter evidence? Firstly, the convincing meta-analyses of Pooja *et al* found that 94% of the studies were conducted in 'WEIRD' countries (Western, educated, industrialised, rich, and democratic), (Pooja Arjawal, 2021). Though further research is always welcomed, I would humbly opine that the cognitive architecture in students in non-WEIRD countries is likely to reflect those in WEIRD countries. Learning new knowledge and skills for all humans, and indeed non-humans, involves practice and re-practice and I would theorise therefore the meta-analyses results would and could be replicated in non-WEIRD countries. On balance, this skewed research base does not dispute whether cognitive science practices are useful in everyday classroom practice.

Secondly, we should consider the EEF report into Cognitive Science Approaches in the Classroom, a Review of the Evidence (EEF, 2021). This review found that 'Cognitive science principles of learning can have a real impact on rates of learning in the classroom. There is value in teachers having working knowledge of cognitive science principles' which was followed with 'the evidence for the application of cognitive science principles in everyday classroom conditions is limited, with uncertainties and gaps about the applicability of specific principles across subjects and age ranges' (EEF, 2021). The second finding led to the review being widely reported as claiming cognitive science was not all that it had initially appeared to be. However, forensic examination of the report shows it positively regards these principles. Again, and rightly, more cross-phase studies should be conducted across a wider variety of subjects, also supported by Moreira *et al* who stated 'more translatable classroom-evidence is needed' (Moreira, 2019).

The largest barrier to usefulness in classroom-based settings is the *fidelity* to Rosenshine's Principles and cognitive load theory. This was captured by Rob Coe (Coe, 2019) as 'my biggest doubt is the Bananarama Principle: 'it ain't what you do it's the way that you do it,' (Higgins, 2018). That is, whilst most teachers will have training on the 'why' they should use cognitive science informed pedagogies, it is often poorly translated to effective classroom practices. This was also captured in the EEF review regarding some applications of cognitive science: 'combining verbal explanations with graphical representations – also known as 'dual coding' – are possible to implement poorly. While some studies show positive impacts on pupil outcomes, there are also multiple studies showing null or negative findings (EEF, 2021).

Fidelity to the principles is therefore the key when trying to answer the question of whether cognitive science is useful in every day classroom practices. The difficulty, I believe, is time may be given to ensure teachers understand the 'why' they should embed these pedagogies, but time is not given to the 'how'. Teachers may understand the theory and may even engage fully with the research that sits

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behind it, but they can quickly lethally mutate the 'how' as there is a lack of iterative and precise training. In my experience across multiple schools, many teachers have reverted to retrieval practice being, at best, a quick review of what students covered last lesson. There is little interleaving of topics, or spaced practice, with most people citing time pressure in delivering the curriculum as the reason for this.

Furthermore, the biggest barrier to effective retrieval practice, even with interleaving and spaced practice, is the consistent lack of assessment of learning that is crucial for it to be an effective classroom practice. This 'checking for understanding' principle is often poorly executed during retrieval practice. Teachers, generally, do not collect quick data to ascertain *who* is getting what *right*. At best, students often give an overall score of, say, three out of five: this is meaningless. Which three? Is it the same three as the student sat across from them? How can teachers know if the material is being embedded into the long-term memory unless they know *who* is getting *what* right and then adaptively teach from there? Use of mini whiteboards or a quick hands up for each question could effectively address this. This anecdotal evidence is supported by the EEF guidance report on continual professional development which indicated that CPD should be iterative (EEF, 2021), endorsing that teachers also have a cognitive load.

Teachers need to be exposed to their own models of 'what good likes' by experts, ideally in subject-specific training, and then have coaching and feedback to ensure these practices become embedded over time within their own. This would ensure fidelity to cognitive load theory and Rosenshine's Principles and mean that students would ultimately benefit. So, this answer is yes, cognitive science is useful in classroom-based practice if teachers are well-trained and adhere to the fidelity of the theory and use excellent formative assessment.

References

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Word count:

1340

Responses to follow-up questions (150 – 300 words total)

Follow-up question 1:

What do you think are the most promising outcomes of utilising cognitive science in a phase or context that is different to your own? (E.g. a different subject or key stage, or for pupils who face specific barriers to learning)

Response:

Using cognitive science informed pedagogies has enormous potential for children with Special Educational Needs and Disabilities (SEND). This was briefly mentioned in the EEF review: 'we have to be aware that students with SEN might become quicker overloaded because of their educational need… Children with SEND, we can still use the approach, just the chunks we still tailor and adapt.' (EEF, 2021). This was a quote from an interview, yet really warrants further rigorous research. For students who have a cognitive and learning need, tight application of Rosenshine's Principles, but with even more modelling, chunking, retrieval, and spaced practice is essential, as well as breaking material into even smaller steps and more checking for understanding. When cognition is impaired, transference to the long-term memory is likely to be more difficult than for mainstream students. But, for students with moderate learning difficulties, cognitive science-informed practices could have a large impact.

For students who fall into the other three SEND areas of communication and interaction; social emotional and mental health, and sensory or physical disabilities, there is broad scope for how cognitive science practices could support them. It is possible these practices would enable students to be more confident and resilient as they realise how much they are able to learn and retain knowledge and skills, to the point where it could be transformative. Further research is therefore essential.

Follow-up question 2 (optional):
Response:

Word count: 222