Practical Techniques for Reducing Cognitive Load in School-Age Children

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Abstract

This systematic review is a consolidation and organization of literature pertaining to the cognitive load theory and its applicability in a classroom setting. Theories such as the flipped classroom, the spacing effect, and learning by teaching have been staples in the classroom for decades, but the literature connecting these theories to cognitive science in a way that is accessible to the teaching community appears to be lacking. While there have been some practical works written for the purpose of providing science-backed teaching methods that explore how cognitive load theory can be utilized in the classroom, most notably a guide written by the government of New South Wales, there may still be room for research. By first describing the theoretical views of how cognitive load affects students in various contexts and then synthesizing practical literature to define and suggest general methods for utilizing these theories in a variety of class subjects, the field of cognitive science can more readily bridge the gap between theory and practice, making classroom applications more informed. The techniques described herein are organized and adapted so as to create an ideal, practical environment that reduces cognitive load, enhancing the educational experience. Practices such as using the CHunking, Ordering, and Patterning (CHOP) technique instead of just chunking, for example, or perhaps writing teaching scripts instead of traditional notes, can be pathways to success that reduce the strain caused by intrinsic cognitive load while enhancing the efficiency of germane cognitive load.

Keywords: cognitive load theory, practical class environment, theory and practice, enhanced educational experiences

The human brain is only capable of storing and actively processing a limited amount of information at one time (Miller, 1994). This capacity for active cognitive processing is called cognitive load. The concept of cognitive load has been officially recognized in the scientific community since around 1988 (Sweller, 1988) and has continued to be an influential component in the way in which both educators and learners approach education, with a vast number of studies presenting important findings that increasingly contribute to our understanding of the way we learn (Ungvarsky, 2024a). While these many studies have improved our knowledge of how cognitive load affects learning, I propose that there are still gaps that could further enhance the applicability of cognitive load theory (Sweller, 2016).

Cognitive load theory (CLT) originated in 1988 whereby a group of researchers led by Dr. John Sweller conducted an experiment involving test subjects performing mathematical calculations by aiming to reach a goal number through multiplying a given number by 3 and subtracting 29 a set number of times (Sweller, 1988, 2016). Sweller (1988, 2016) and their team noticed that, although the subjects had high success rates when doing these calculations, very few of the subjects became aware of the pattern presented to them. This, to the researchers, was evidence of a high cognitive load making any additional cognitive processes difficult to initiate. Thus began the concept of CLT (Sweller, 1988, 2016).

Cognitive load theory, though it has already been 37 years since its inception, potentially still has a long way to go before its applications in a classroom setting can be fully realized

(Ouwehand et al., 2025; van Merriënboer & Sweller, 2005). Moreover, while there is a body of research that backs up, improves upon, and alters CLT, many of these studies have related to very specific focuses. For example, some research places an emphasis on using technology to reduce cognitive load (Toh & Tasir, 2024), while other studies emphasize a particular aspect of mathematical practice (Cory & Ray, 2023; Toh & Tasir, 2024). Since there are diverse research reports in the literature in the field, synthesizing the information from these data can be beneficial in uncovering underlying factors in the quest to determine a more encompassing set of rules for educators to utilize.

The purpose of my systematic literature review is to examine the findings from research conducted within the realm of CLT and synthesize the literature into a more manageable, applicable set of common philosophies or techniques that a teacher can use to more effectively engage students, enable a higher rate of retention among students, and potentially encourage more successful academic performance. Factors such as student engagement, working memory capacity, motor task performance, and several others are all influenced by cognitive load, meaning that attention, retention, motor skills, and others are possibly affected by cognitive load, along with the development of these important functions (Buckley et al., 2022; Ninomiya et al., 2024; Winthrop et al., 2025). By understanding which methods best compliment learning through the lens of CLT, students and professionals can reevaluate their own abilities and improve such functions in a real-world setting (Szulewski et al., 2021). The goal of helping teachers to facilitate learning by gaining knowledge and techniques in relation to CLT is to enhance teaching and learning in real classrooms that will carry offer to life outside of school (Centre for Educational Statistics and Evaluation, 2011).

Theoretical Background

Before I can begin to break down the studies and compare data, I must first define the types of cognitive load in order to avoid misunderstanding when developing practical rules for applying this theory in the classroom. Pande (2022) identified three different types. First, intrinsic cognitive load refers to the unavoidable and fixed level of cognitive effort required to perform a task. It is only influenced by the already-existent abilities of the learner. Second, extraneous cognitive load is best defined as the load placed on a learner due to inefficient or unnecessarily difficult learning tasks and/or environmental distractions. Third, germane cognitive load is the effort in using one's resources and mental processes to facilitate learning of the task being presented. When teachers and students understand the types of cognitive load, both teachers and students can then enhance specific ways to work successfully with cognitive load (Pande, 2022). An example can illustrate each of these types of cognitive load. When a learner of English as a foreign language is tasked with understanding a written sentence, the intrinsic cognitive load is the proficiency required to make meaning of each word within the sentence. Extraneous cognitive load could be the learner's current circumstances at home, affecting his or her concentration, distracting the learner. Germane cognitive load could be the learner inferring the meaning of words within the sentence based on context or previous knowledge.

For my review of the literature, I will focus on intrinsic and germane cognitive load. Studies relating to extraneous cognitive load will be omitted, as this type of cognitive load is often the result of external factors indirectly and circumstantially connected to a classroom environment and of which teachers have little control.

Foremost, when considering cognitive load, strategies should be used with students in their classes to help reduce cognitive loads. Alleviating the effects of high cognitive load (e.g., reduced working memory capacity, impaired learning and retention, increased frustration and anxiety, surface-level processing, decreased academic performance) is crucial for student learning. There are several teaching strategies for alleviating high cognitive load including chunking, scaffolding, structuring, and visual aids (de Jong, 2010). While these are commonly used teaching strategies, they are rarely used to reduce cognitive load because educators are unaware of their applications for this issue. (de Jong, 2010). Thus, reevaluating and reimagining the applications of these methods can have valuable impacts on the education system as a whole, if presented in a more unambiguous way.

Stress Management

Intrinsic load has been connected to subjective stress levels, indicating that it may be an educator's responsibility to reduce stress placed on a learner in order to assist the learner in performing tasks at a relatively high level (Almarzouki, 2024). Stress is often associated with increased physiological markers such as pupil dilation and tachycardia, defined as an increased heart rate, which, while these physiological adaptations are often correlated with improved performance, prolonged exposure to stress results in an impairment of synaptic plasticity in the hippocampus, an area responsible for learning and memory (Almarzouki, 2024; Ekin et al., 2025: Skulmowski, 2023). However, other studies have concluded that acute challenge stressors used in positive ways may have a positive impact on the performance of individuals in a task performance context (Kubicek et al., 2023). These research results suggest that intrinsic cognitive load is influenced at the individual level and shaped by many factors, including exposure time, individual resilience to stressors, and the task being performed (Ayres et al., 2021). Therefore, it seems reasonable to infer that in order to properly reduce the high subjective cognitive load on a student, one must consider several factors: the individual's resiliency, the acuteness and severity of the stress, the degree of stress already present in the subject, and the perceived difficulty of the task at hand (Ayers et al., 2021). It seems to be important for teachers to be able to develop ways to understand and work with each student as they develop learning experiences for our classes.

Working with individual cognitive loads and stressors may appear to be impractical in the context of a classroom, as each factor is measured on an individual scale. However, rather than completely mitigating stressors in the classroom as a blanket action, educators can use stressors strategically and in line with the research. First, educators must understand that acute and chronic stressors play opposing roles in performance. According to Fogt et al. (2010), finding the correct combination of stress and support is crucial for student success, while chronic stressors, regardless of the source, have been shown to reduce cognitive functioning. For teachers and students, reducing chronic stress and employing appropriate acute stress may have the most beneficial influence on utilizing cognitive load to the advantage of students' academic performance.

How do teachers develop the proper amount and types of stress in the setting of a traditional classroom? For example, if there is an important test approaching, it may prove more effective to create an atmosphere where students can feel most at ease, such as providing additional support in the form of helpful review lessons or being readily available when students have questions regarding the content. Teachers can help students deal with acute stress by using strategies such as gamification during review lessons or a competitive study session. In reality, a teacher knows their classroom dynamics best, and the resiliency of students and the tasks required of them are likely best known by the teacher (Fogt et al., 2010). From my experiences, to properly use a strategy like this takes careful planning, but it may prove highly effective if implemented in an environment in which students feel safe.

Intrinsic Cognitive Load

Intrinsic cognitive load is defined as the inherent complexity, characteristics, and demands of the content being learned (de Jong, 2010). For example, material to be learned that is highly interactive and requires a large degree of mental work to complete is considered to have a high intrinsic cognitive load when compared to a task that demands little activity or is straightforward in its design (de Jong, 2010). When more cognitive resources are required to complete the task, the internal cognitive load increases (van Merrienboer et al., 2003). Additionally, intrinsic cognitive load also depends on the way in which learning material is presented. For example, if learning content is presented in a way that builds up from simple concepts to more complex material, the intrinsic load is lessened (van Merrienboer et al., 2003). By understanding the sources and effects of intrinsic cognitive load, educators can identify and implement strategies to reduce this load.

Chunking

A practical method of memory retention that many educators in the realm of mathematics are likely familiar with, but can be used in a number of ways in many areas of study, is chunking. Chunking is the process of grouping large amounts of information into smaller more manageable sections, or chunks, to aid in the retention of this information (Ungvarsky, 2024b). Using a chunking method requires relatively little experience or training, and can be taught within a comparatively short timeframe, making it an effective practice to add to any lesson. Chunking has the benefit of alleviating the cognitive load placed on an individual by turning large quantities or varieties of information, which is limited by our brain's capacity for storing data, into fewer, more structured information (Edwardson, 2024), which essentially "frees up" space to perform more cognitive tasks (Edwardson, 2024). Therefore, chunking is a vital part of increasing our cognitive efficiency, which reduces load very much like defragmenting a computer.

How can chunking be useful in a classroom? Many teachers are familiar with chunking in terms of remembering long numbers such as phone numbers and math problems, or acronyms that assist in remembering science concepts and historical events (Edwardson, 2024). However, chunking can be useful for the retention of other subjects, such as foreign language acquisition or even music and art (Godøy et al., 2010). While chunking itself is well-known and can be adjusted and applied to any subject with relative ease, at its core, it is not so far away from memorizing encoded information. For some time now, strict memorization has been losing popularity in the educational worldview, being replaced by more intuitive and holistic methods (Azzam & Easteal, 2020).

In order to more effectively utilize chunking for the purpose of reducing the cognitive load in learners, I researched ways to not only chunk but also organize and develop connections. This is where the CHOP technique comes in (Syn & Batra, 2013). CHOP is an acronym for "CHunking, Ordering, and Patterning" and refers to the brain's natural tendency to find patterns in seemingly unrelated information (Syn & Batra, 2013, Abstract). Using the CHOP technique, educators can lead instruction by following a few simple steps which take only slight preparation. First, by chunking the information into more manageable groups, learners have an easier time remembering larger amounts of information. Next, ordering these groups into categories makes it easier for a learner to understand the values of each chunked group. Finally, learners can then discover patterns related to every group's interaction with each other and form connections for assimilating and drawing conclusions based on this knowledge (Syn & Batra, 2013). For example, when introducing a new sentence structure in a foreign language class, educators can break the pieces of the example sentences into phrases, effectively chunking the information to ease learning (Syn & Batra, 2013). Then, the learners can work together with the teacher in ordering these phrases into groups based on similarity or position within the sentence. Finally, the teacher can guide the learners in discovering what makes these sentences accurate and why, by synthesizing the chunked and ordered parts of speech. Chunking as a stand-alone teaching method is a useful tool in education, but if the goal is to also rouse critical thinking, I believe the CHOP technique is a beneficial expansion on chunking (Syn & Batra, 2013).

Scaffolding

Another approach for reducing the intrinsic cognitive load for learners is scaffolding. Scaffolding encompasses a large range of philosophies and teaching strategies, so, in this literature review, I will highlight practical applications. The goal of scaffolding is to provide a systematic approach to learning in a way that helps to reduce the gap between previously-acquired knowledge and the knowledge being introduced, also known as the zone of proximal development, or ZPD, first made popular by Soviet psychologist Lev Vygotsky in the 1930s (as cited in Flair, 2024). Scaffolding has been observed both to enhance creative performance through stimulation of the prefrontal cortex, and improve instructor-learner interbrain neural synchronization, allowing a teacher to better understand the possible next steps to take in the instructional process (Jin et al., 2024). Moreover, properly utilizing scaffolding techniques has been shown to positively affect student engagement and psychological well-being, possibly due to the improved synchronization between instructor and student (Jin et al., 2024).

What can be done in a classroom to best use this effect to our advantage? As previously mentioned, scaffolding is a term used to describe a variety of techniques. However, a few practices stand out as more effective (González-Calero et al., 2015). For example, application activities, or the hands-on experiential learning of a concept using projects, experiments, or simulations, have been shown to exhibit a greater effect on retention and recall when compared to books or even games (Huang et al., 2023). Furthermore, a practice called intensive scaffolding, which is a subtype of scaffolding whereby the instructor gradually reduces their interventions by giving students more freedom and power in their formulation of a solution to presented problems, appears to be more effective at improving learners' ability to understand and retain information (Gonzalez-Calero et al., 2015). In the context of cognitive load, these two techniques seem to have synergistic effects, giving students more opportunities to build their skills and confidence (Huang et al., 2023).

By creating an environment where a teacher presents a real-world problem requiring students to work on a solution and assists students in the work necessary to solve this problem, the initial cognitive effort needed of the students is lessened (Gonzalez-Calero et al., 2015). After students successfully work with the teacher to solve a problem, the practice can take place again, but with less help from the instructor. The process can be completed as many times as necessary until the students are able to work through similar problems on their own. From an intrinsic cognition standpoint, the subjective difficulty of the concept is diminished gradually while the working memory of the students relating to the concept is enriched through the combination of these techniques (Gonzalez-Calero et al., 2015).

An example of this may be an art teacher presenting a primary school art class with directions to create the secondary colors orange, green, and purple, and place the primary colors in front of students. At first, the teacher can show them how to create one of the colors through mixing. Next the teacher can work with students in small groups to work together for each group to create the secondary color. Then the teacher may leave it up to each group to create the third secondary color. Since research has demonstrated that these best practices of application activities and intensive scaffolding are valid, this should instill a deeper memory of color combinations, while reducing the perceived cognitive load on students through initial intervention by the teacher. These kinds of techniques give students opportunity to learn important curriculum in ways that ensure that cognitive load is lessened and student confidence is raised. (Gonzalez-Calero et al., 2015).

Structuring

It is important for teachers to consider cognitive load as we structure (e.g., design activities, order of teaching a topic, order of activities within a lesson, omit task switching activities) our lessons. Proper structuring of lessons, classroom activities, and overall curriculum design necessitates a multifaceted view of teaching. One of the factors that influences the order and structure of a lesson is the potential for task switching. Task switching is exactly what it sounds like—switching from one task to another (Lu et al., 2019). Task switching places a heavy demand on the cognitive load of an individual mainly due to a phenomenon called the “switch cost effect” (Lu et al., 2019). This effect can be witnessed frequently and clearly when viewing a bilingual individual switching between languages. The costs of switching tasks are generally observed as being due to the stresses imposed on an individual relative to the difficulty of the process being switched to (Lu et al., 2019). The greater the difficulty of the processes, the higher the stress level and subsequent switch cost of the individual. This suggests that the increase in cognitive load is a result of factors both within and outside of the individual’s control.

On the other hand, dual-tasking, or the ability of a task performer to handle multiple tasks at once, is also often mentioned as coming with a cost to performance, usually attributed to competing areas of the brain responsible for both tasks (Mac-Auliffe et al., 2021). While dual-tasking likely is also influenced by the relative difficulty of the tasks, there exists a third factor to be considered here, according to research. Those who switch between singular tasks pay a certain cost to performance, but those who switch between performing multiple tasks at once are under greater cognitive load (Mac-Auliffe et al., 2021). While the idea that performing multiple tasks simultaneously requires more brainpower may seem obvious when looking at real-world scenarios, it warrants weightier reflection in the context of learning in a classroom setting. For example, Sousa (2022) explained that some research has determined that multiple tasks cannot be done simultaneously; each task ends up in a task switch.

An example of this in the classroom can be in a foreign language study class. Bultena et al. (2014) reported that switching from language one (L1) to language two (L2) resulted in larger switch costs than from L2 to L1, and the less proficient a learner's L2, the higher the cost of the switch. There are two factors at work in this case. The subjective stress level of the learner is probably proportionate to the proficiency of the learner's L2, assuming their resilience is controlled. As already mentioned, stress increases cognitive load. Secondly, language learners often develop listening skills at a faster rate than speaking skills, making it easier for an individual to hear a sentence in L2 and convert it to L1, rather than the other way around. But what if a task were introduced that required dual-tasking? For instance, requiring a learner to listen to a story in L2, and answer critical thinking questions in L2 in writing?

Task switching is a practice that often appears in a foreign language-learning class, as students are required to exhibit listening comprehension in written examinations. When students must listen to another language and then write responses to written questions in their assessment activities, there is the potential to dramatically increase the cognitive load on students, as these tasks combine dual-tasking with task-switching. Should this be avoided? In fact, it probably cannot be completely avoided, as it is an instrumental part of language (Bultena et al., 2014). However, the cognitive effects of this dual-tasking and task-switching can be reduced by implementing an increasingly accepted method of teaching called the “flipped classroom” (Etemadfar et al., 2020).

A flipped classroom is simply a learning model whereby students learn material prior to coming to class, then later being instructed on it or led in a discussion about it in the classroom. The teaching model, while relying on students’ autonomy and self-motivation while outside the classroom, is an effective measure for decreasing the cognitive load on learners if done properly (Etemadfar et al., 2020). But can it be implemented in a setting where students have little time to study at home? The underlying techniques of a flipped classroom can be adjusted to fit within a single lesson as well.

One potential practical option for flipping an individual lesson is to first guide the students in reading through and understanding the critical thinking questions before beginning the listening comprehension story (AlAli et al., 2024). This activity is, at its core, the same principle as a traditional flipped classroom, and many educators already use this technique without equating it to a flipped classroom, and it is highly effective at reducing cognitive load for students. By ensuring the students are prepared to listen for specific answers to the written critical thinking questions, the task of reading and understanding the written questions transitions from a dual-task to a task-switch, helping to alleviate the stress and the additional cognitive cost brought upon by dual-tasking.

Germane Cognitive Load

Germane cognitive load involves students taking what they already know and use their knowledge and skills to learn new material. In germane cognitive load, the more students understand and know, the more effectively they can learn new material. If teachers can help students connect their already developed skills, mental schemas, and knowledge to new learning, the more likely their new learning will make sense and have meaning for students (Costley, 2020). Through these techniques, the cognitive load placed on students can be minimized through more holistic practices that accentuate a learner's ability to comprehend and then analyze information.

According to Greenberg and Zheng (2022), there is conflicting evidence on whether or not germane load itself should be separate from intrinsic or extraneous cognitive load, in that there is little effect on the performance outcome of tasks in subjects with a high capacity for intrinsic load versus those with a low capacity in a task when germane load varies. It can therefore be speculated that it is not simply a matter of effort when performing a task, but the preparedness of a student. If a learner has high germane resources (e.g., knowledge, skills, schemas), then the amount of mental energy being utilized to perform a certain task is lessened, making the overall cognitive load easier to manage in theory (Greenberg & Zheng, 2022).

Furthermore, the level of preparedness can vary greatly from individual to individual. When students have a more solid foundation of knowledge and skills, it has a positive impact on the average cognitive load of the learners within a classroom. The influence of germane resources is an important variable in learning (Klepsch & Seufert, 2020). To summarize, the preparedness of a learner can potentially compensate for the intensity of the intrinsic load presented to the learner and the effort that the learner puts forth in their task.

From a practical standpoint, increasing germane resources can lower overall cognitive load, meaning that by providing learners with methods that complement the structure of learning, educators can decrease the stress and improve performance of learners in an education experience (Costley, 2020). By exploring the techniques that drive efficient and focused learning such as spaced repetition, retrieval practice, and knowledge sharing, cognitive load can be managed and efficient learning can take place. While the techniques presented here will be steered toward germane load, it is also vital not to emphasize one type of load over another, as each one plays its own role in the bigger picture of student success. Therefore, when examining the benefits of the following teaching methods, it is important to understand their function and use them collaboratively with other techniques described here in order to form a more complete classroom experience. Put simply, there are times to use one technique, there are times to use others, and there are times to use multiple techniques.

Spacing and Micro Learning

One method worth considering is the spacing effect (Chen et al., 2018). It can be seen most notably in language learning apps and advertising, whereby the information is provided, then a specific amount of time relative to the degree to which the information is understood passes, after which the information is repeated. This process has been observed to have positive outcomes in assessment scores, especially when compared to traditional studying methods that generally expect a learner to understand a concept fully and in only one span of time, but for longer periods of time within that span (Chen et al., 2018). The spacing effect is a useful tool that utilizes the brain’s tendency to grow more familiar with repeated information exposure to facilitate learning.

Chen et al. (2018) discussed the spacing effect which has applications for teaching to reduce cognitive load. To explain in a more basic sense, the typical method for succeeding academically is to "cram" information immediately before an assessment, enabling the learner to recall the information during test time. However, the spacing effect posits that this is not the most efficient method for learning a concept fully and deeply. No matter if the content is related to simple vocabulary lists or more involved knowledge like scientific constructs, the benefits of spacing out the information has been shown to improve memory retention, reducing the germane cognitive load by allowing for more effort to be placed on learning the information that has not been mastered and less effort on those that are already retained (Chen et al., 2018). The underlying mechanism for this can be understood on a neurophysiological level.

When information is rehearsed on several occasions over a period of time, neural networks grow new synapses that help to reduce the effort needed to recall the learned information (Knoblauch, 2009). However, when this same information is rehearsed only once in a longer duration, the growth of new synapses is only slightly more than if the information had been taught for a shorter duration in line with spaced repetition (Knoblauch, 2009). For example, if Learner A studies for 10 minutes three times this week, and Learner B studies for 30 minutes once, the number of new synapses increases by the same amount in both learners (Knoblauch, 2009). Therefore, it can be argued that repeated exposure to a task or information can have similar benefits as prolonged single exposure, at least on a neurophysiological level.

How can teachers use the spacing effect to our advantage in a classroom setting, where time is limited and expected goals are standardized to a systematic scale? As previously mentioned, the spacing effect has been used for very specific applications such as language learning apps, but can be adapted to better suit more experiential subjects, like music or science.

It seems that spacing can be used in most cases in which students are learning new material. Learning of songs can be enhanced by temporally spacing practice sessions, which has been shown to improve working memory and increase retention of the words in the songs themselves when compared to a singular mass practice (Carpenter et al., 2022). Most interestingly is that the duration of breaks between practice seems to have little effect on the degree to which the songs are learned, up to a reasonable point (Katz et al., 2021). So, in the context of music, breaking the song into manageable blocks and spacing out the practice of such blocks instead of whole song practice can potentially have a comparatively advantageous effect on the retention of the song in its entirety.

But what about subjects that often rely on more hands-on learning, such as science? In the ever-shrinking windows of time in which most educators have to teach any given lesson, experiential learning may need to be replaced with more time-efficient but less stimulating activities. One way to combat the cognitive load placed on students who are being increasingly exposed to more information with less time to understand and recall this information is by using a simple technique referred to as microlearning (Yuan, 2022).

Micro-learning can be described as breaking the time spent learning into smaller chunks, allowing time for small breaks such as quick exercise activities or alternative learning experiences; anything to create a break in the streamline of the learning structure for a short while (Yuan, 2022). This differs from chunking in that chunking refers to the breaking of information, while micro-learning refers to breaking up the time (Yuan, 2022). This has the benefit of redirecting attention into other areas of the brain for a brief moment, simulating the practice of a longer period of time being spent between studying. In this way, multiple periods of study can take place within a shorter period of time while still benefitting from the spacing effect on a neurological level.

Retrieval Practices

Agarwal et al. (2014) described retrieval practices as having students recall information from their memories rather than rereading information. This process of learning helps students to actively engage with material through recall, and students deepen their understanding and improve their ability to retain and apply knowledge over time. Students also can gain insights into where they have gaps in their knowledge.

Looking at the common, yet misunderstood application of retrieval practice, there are several strategies that can be applied, most notably practice testing (Agarwal et al., 2014). Practice testing is simply providing students with an opportunity to review material in the format of a traditional test, but without the implications such as test scores that average into the student's final grade. Practice testing has the benefit of reducing anxiety, which is a stressor ever more prevalent in schools today (Agarwal et al., 2014). Stress, as mentioned previously, subjectively raises cognitive load, so a reduction in anxiety could have potentially significant impacts on the level of cognitive load on an individual (Carpenter et al., 2022). Considering the impact practice testing has on reducing stress levels, it follows that by introducing practice tests that more closely mimic the real tests instead of worksheets that may have different formats or structure, a teacher can passively reduce the cognitive load in the classroom (Agarwal et al., 2014).

But why does practice testing have such an impactful influence on a learner's ability to recall information? The answer lies in efficiency; a learner becomes more efficient at answering questions if the topic and format of testing is familiar to them (Rawson & Dunlosky, 2012).

However, without support from teachers or peers, learners often assume that practice testing is meant more so for monitoring of success rather than as a vehicle for improving recall of information (Rivers, 2021). Because of this challenge, further implementation of other tools for improving germane load may also be necessary.

Learning-by-Teaching

Learning-by-teaching is an effective strategy for helping to ensure that the combined experience of everyone involved can be fully utilized, which saves time of course, but from a cognitive point of view, this effect has another bonus. It is well known that teaching others has the added advantage of increasing one's own retention of information (Carpenter et al., 2022). The cause of this seems to be mainly rooted in psychology. According to Frankenstein et al. (2022), self-efficacy plays a role in the ability of learners to recall information, and by believing one has the knowledge necessary to teach others, an individual is more capable of showcasing this knowledge in assessment or practice. This facet of self-efficacy is in line with other studies suggesting that learning by teaching creates an environment whereby more inspired questions are asked, facilitating learning (Wong et al., 2023). Therefore, learning-by-teaching has numerous benefits ranging from increased self-efficacy to enhanced creativity.

So why do collaborative learning techniques such as learning-by-teaching have such a powerful influence on memory and cognition? The answer lies somewhere in the brain's preference to organize information and consolidate it into networks that are more readily retrievable (Larsen, 2018). This can likely occur as a result of the learner's understanding that recall of this information is imminent, therefore consolidation is necessary for the accurate expression of such information to others. This probably stems from a desire to be acknowledged by peers. If the information a student provides is inaccurate, then credibility may be harmed.

Essentially, it is the brain's social survival need that brings about this consolidation of learning content.

In practice, having a multitude of students in one classroom simultaneously teaching each other is a challenge that can be overcome by several methods, notably the jigsaw method, which divides the class into an appropriate number of groups focusing on one topic each that then go on to teach each other (Samangun et al., 2024). This strategy, along with other role-playing techniques, has been shown to improve scores across a wide range of subjects, including language acquisition and forensic science (Kumar et al., 2024). This style of learning-by-teaching is both time-efficient and effective for utilizing the self-regulation of the learners.

Educators must address the problem stated previously that there often is not enough time for an entire classroom to learn by teaching. Teachers can help with time issues with note-taking under a certain pretense. An instructor can get the most out of a simple lecture in which students are expected to take notes by stating that the notes being taken will be used to teach others. This method of "silent teaching" is an effective strategy for minimizing the problem of having so many students verbally teaching their learned content within a classroom (Lim et al., 2021). Silent teaching basically provides the benefits of learning-by-teaching without the subsequent teaching aspect, thereby saving time.

While teachers may be associating learning-by-teaching with students literally instructing their peers in the manner that a teacher might, students can take notes and create their plan for teaching. This teaching script is potentially almost as valuable as actually teaching other students. As students are learning, they take notes and create a teaching script or plan. After teacher-led instruction has finished, accountability measures can take place, such as randomly selecting a student to share their script, or having all students swap scripts with their peers. In this way, students are more likely to feel motivated to provide accurate information with the added benefit of both consolidating thoughts and possibly asking more creative questions within their scripts.

Summary

The practical applicability of reducing cognitive load in an effort to improve the learning experience of school-age students is one that receives a lot of attention, but rarely have there been systematic reviews encompassing such an extensive set of generally useful teaching methods. The information shared within this review has been researched extensively and, while not all of these techniques can be utilized at the same time, one or a mix of the most necessary measures can be included in any traditional classroom environment without being too far removed from what is commonly accepted as universally appropriate pedagogical teaching. For example, if one were to try to implement all the methods mentioned within this review, it might look something like this:

- A teacher can use the CHOP technique to break down the information into parts and order them in a way that takes less effort to remember (Syn & Batra, 2013).
- Pre-teaching some of the material under the established direction of a flipped classroom can reduce the switch cost often accompanied by switching between tasks frequently in a lesson (Etemadfar et al., 2020).
- Having the students write their own teaching scripts instead of notes can further enable learners to consolidate information more efficiently (Lim et al., 2021).
- Through instructor-led application activities whereby the instructor gradually removes themselves from the activity, teachers can get a better sense of student

understanding through what is essentially relationship-building (Gonzalez-Calero et al., 2015).

- Appropriately spacing out the learning material, whether it be several days or even micro-learning within the span of a single lesson can increase retention rate through synaptic growth (Knoblauch, 2009; Yuan, 2022).

The techniques stated in this review can ultimately help students and teachers manage cognitive load and effectively assist learners in “freeing up space and effort” in their own minds.

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