Instructional Approaches That Reduce Cognitive Load

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Reducing and managing cognitive load is an effective way of supporting working memory functioning and enhancing learning and performance in the classroom (de Jong, 2010). Reducing the processing demands in the learning environment will help impaired students overcome the working memory limitations that are impacting their learning (Elliott, Gathercole, Alloway, Holmes, & Kirkwood, 2010). The extent of cognitive load during any learning task depends on the teacher's instructional methods, the learner's internal processes, and the nature of the content and structure of the materials (van Gog, Ericsson, Rikers, & Paas, 2005). When teachers learn to better recognize the specific cognitive load variables within each of these three areas, they can more effectively design instruction and select curriculum to minimize load. They also will be able to more effectively teach students how to better manage their internal cognitive load.

Content and Materials

The amount of cognitive load arising from the nature of the content and materials is determined by:

1. the amount of material and the difficulty and complexity of the subject matter. Smaller units of information require less integration and relational processing, and there also is less information to maintain while processing. More difficult and complex material requires more resources to process, but the processing challenge may be ameliorated somewhat by expertise in the subject matter.
2. the sequencing of the material. Material sequenced from simple to complex minimizes load as the student progresses through the material.
3. the novelty of the subject matter. The less prior knowledge the learner has, the greater the load.
4. the organization of the materials. Requiring the learner to integrate disorganized materials will add significantly to the load. For example, simply presenting the information on multiple sheets of paper increases processing demands because the learner must combine several sources of information (Jang, Schunn, & Nokes, 2011).
5. whether the information to be processed and the information to be remembered are the same or different. For instance, the learning objective may be to recall the capitol of each state, but the materials may require the student to locate each capitol on a map.

Procedures for Reducing This Type of Cognitive Load

1. providing worked examples or partially completed examples, such as a completed mathematics problem. Having the examples available also reduces the need to hold several elements in temporary storage.
2. arranging and integrating the information so that there is only one source. If multiple sources of information must be used during a learning task they should be arranged in a side-by-side fashion (Jang, Schunn, & Nokes, 2011).
3. presenting arithmetic problems vertically, rather than horizontally (Alloway, 2011).

4. providing materials that allow the student to focus on processing without the need to maintain task-relevant information. Keeping lists of information or procedural steps in view reduces working memory load. Written reminders of problem-solving steps reduce problem-solving search and evaluation strategies that impose a heavy cognitive load. Other examples include number lines and a list of frequently misspelled words (Gathercole & Alloway, 2008).
5. beginning with just a few elements that can be learned in isolation and gradually adding more.

Instruction and Teaching Behaviors

The amount of cognitive load arising from the type of instruction and from teaching behaviors is determined by:

1. the instructor's language and verbosity. Wordiness and complex language add extraneous processing load to the task. Simple, concise, consistent wording allows the learner to focus on the required processing (Gathercole & Alloway, 2008).
2. the length of the lesson. Lengthy lessons create more proactive and retroactive interference as more and more information is added. The need to inhibit interference adds to cognitive load.
3. the organization of the instruction. Well organized instruction makes fewer demands on the learner's processing.
4. how well the teacher elaborates. Elaboration is the process of explicitly linking new information to prior knowledge in a manner that helps the learner understand the relations.
5. the amount of time allowed for processing and maintenance. Students who are allowed more time have more opportunities to switch between processing and rehearsal.
6. how much secondary processing is required. For example, a student listening to a lecture is processing the information in order to comprehend it and associate it with related schemas. The requirement to take notes while listening adds the processes of transcribing words and converting thoughts into notes.

Procedures for Reducing This Type of Cognitive Load

1. maintaining a quiet learning environment. The need to inhibit interference from distractions increases processing load.
2. differentiating instruction such that the processing demands are appropriately matched to the individual learner's working memory capacity.
3. utilizing structured teaching approaches, such as *Direct Instruction*, that have built-in repetition so that the learner can focus more on the processing dimension and less on maintenance.
4. avoiding presentation, or even mention, of non-essential or confusing information in order to reduce unnecessary processing. All information and required processing should be germane to the task or the material to be learned. Procedural steps should not be presented until they are actually needed.
5. presenting material both verbally and visually may reduce processing challenges in students with a relative weakness in one modality (de Jong, 2010).
6. requiring the student to focus on only one process at a time. Multi-tasking should be avoided.

Learner's Internal Processing

The amount of cognitive load arising from the learner's internal processing is determined by:

1. how much internally generated interference needs to be inhibited and the individual's inhibition ability. The need to inhibit irrelevant associations and thoughts adds to cognitive load.
2. the learner's levels of mastery, expertise, and prior knowledge. The less developed these are, the greater the amount of processing required.
3. other cognitive factors related to working memory performance, such as the learner's processing speed and fluid reasoning ability (Dehn, 2008). Slow processing speed will increase cognitive load and decrease retention because rehearsal cannot occur frequently enough.
4. the use of well-developed memory strategies, such as chunking. Strategies that are mastered and automated can function effectively without creating significant processing demands.
5. the level of metamemory development (Dehn, 2010). Learners with advanced understanding of memory functions, cognitive load, and their personal memory weaknesses can make informed decisions and selections to regulate the type and amount of processing they engage in during learning and working memory tasks.

Procedures for Reducing This Type of Cognitive Load

1. guiding the student through schema construction and modification. Such guidance might include helping the student to classify, interpret, exemplify, differentiate, and infer (de Jong, 2010).
2. allowing the student to self-pace learning and allowing ample time to complete the processing required for the learning task.
3. teaching the learner how to minimize cognitive load. For example, the student should be informed that listening to music while studying adds to cognitive load, thereby interfering with learning and task completion.
4. teaching the learner how to cope with cognitive load in a manner that improves retention. For example, the learner should be taught when and how to switch from processing to maintenance of information.
5. encouraging the student to ask for help when it is too difficult to process and retain information simultaneously.

Isolated application of any of the procedures recommended above should be helpful, but the more that are applied, the greater the reduction in load. In general, learners will have difficulty maintaining information in the short-term and encoding it into long-term memory whenever the learning task requires them to engage in an attention-demanding processing activity. Students with impaired working memory can learn effectively if they have ample exposure to material while demands on working memory are minimal. That is, students learn best under low cognitive load conditions.

Perhaps, nothing reduces cognitive load more than the acquisition of automaticity (Dehn, 2008). A task or procedure is said to be "automated" when it is overlearned or mastered to the point where it can be performed without conscious, mental effort. Automaticity speeds up processing, reduces cognitive load, and increases retention of information because the processing involved requires little attention. A prime example is the acquisition of reading fluency. A fluent reader has automated word decoding processes that "free up" working memory capacity for processing, such as

making inferences, and for retaining more information, leading to better reading comprehension.

Students with working memory deficits may require more than methods that minimize cognitive load. They may need additional, individualized interventions and accommodations that support working memory and allow them to learn and perform better. These include: frequent repetition, re-teaching, and review; providing more support, such as scaffolding, during the initial stages of learning when cognitive load is higher; helping students monitor the quality of their work; providing advance organizers; structuring information in a manner that encourages and supports the use of memory strategies; helping students complete challenging activities; supporting the development of schemas; and teaching working memory strategies and encouraging their use.