Cognitive load theory, which states that the brain can only handle a limited amount of new information at a time, was developed by English researcher John Sweller in the late 1970s during his work with students and problem-solving experiments, and has been refined and clarified by various researchers since then. It is now a widely-used, research-based set of principles used to design more efficient instruction.

The theory has its roots in the study of memory: all human learning uses two memory types -- working memory, and long-term memory. Working memory is the active component; its main role is conscious processing, while long-term memory is the main knowledge repository. Working memory has very little storage capacity, and is easily overloaded if too many pieces of information are brought in at one time.

The limits of working memory capacity were first introduced in George Miller's 1956 paper, “The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information” in which he proposed that we could only hold five to nine (seven plus or minus two) pieces of information in our working memories. Building on Miller’s work, in 1973 Chase and Simon used the term “chunk” as they described how humans see chunks as patterns and relate them to other patterns, which forms knowledge. Then in 1976 Sweller wrote, “The effect of task complexity and sequence on rule learning and problem solving” in which he detailed research indicating that students learned better when performing worked examples (instructional devices that provide an expert's problem solution for a learner to study) than when trying to find the solutions to the problems all by themselves. Sweller divided his students into two groups: the “problem group” which was given lots of problems to practice while another group, the “worked example” group, was given the same problems, with the solution for
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The work example group did better than the problem-solving group. Sweller attributed this to the minimization of cognitive load.

Sweller and others continued testing and revising the theory over the next few decades. He and others demonstrated several related effects, including the split-attention effect, the redundancy effect, and the modality effect.

The split attention effect occurs when the learner must split his/her attention between multiple sources of visual information that have to be integrated for comprehension because the individual sources cannot be understood by themselves alone. Mental integration imposes a considerable cognitive load on working memory, especially when the two information sources are spatially separated rather than spatially integrated. Sweller et al. found the extraneous cognitive load of separated sources of information can be considerably reduced by integrating the two sources of information as far as possible.

The redundancy effect grew from the split attention effect. When the same information was merely repeated in a different form, cognitive load was increased by having to unnecessarily coordinate both sets of information, regardless of whether they were integrated or not. The best way to reduce extraneous cognitive load was to eliminate the redundant version.

The split attention effect also led to the modality effect. It had been known for some time that both auditory and visual working memory can be used simultaneously and that, in combination, the use of both processors increase the capacity of working memory to some extent. Eliminating split-attention is important in all instruction.

Initially, the theory and the demonstrated effects were mainly concerned with “extraneous” cognitive load, cognitive load that was under the control of the instructional designer. Intrinsic cognitive load, the load that is caused by the nature of the material, is thought to be outside of the control of the instructional designer. In the early to mid-1990s, Sweller and his peers realized that some effects, such as the split attention, redundancy, and modality effects, could not be obtained with some materials. They discovered that the effects failed when the nature of the material was such that it can be processed in working memory one or two elements at a time. If intrinsic cognitive load was low due to low element interactivity, it hardly mattered what the instructor did because working memory was not overloaded. In other words with a low intrinsic cognitive load, extraneous cognitive load didn't matter. They called this affect the element interactivity effect.

In 2002, they realized that there had to be ways of reducing intrinsic cognitive load, otherwise very complex material could never be learned. They modified the theory to say that you can reduce intrinsic cognitive load, but you cannot simultaneously maintain full understanding. However, the small bit that has been learned by the reduction in intrinsic load can be integrated with other small bits learned and will therefore promote learning. By presenting material with some interacting elements initially omitted, learning can be facilitated. They called the effect the isolated -- interacting elements of fact.
A third form of cognitive load, germane cognitive load, was discovered after cognitive load theory attracted international interest. Dutch researchers Fred Paas and Jeroen van Merrienboer in 1994 found that if they gave learners work examples that differed considerably in variability, cognitive load was increased compared to work examples that were all quite similar. However, despite the increasing cognitive load, high variability worked examples resulted in better learning than low variable military examples, giving the variability affect. They labeled this form of cognitive load germane cognitive load because it was a load that was germane to schema (mental structure) acquisition and automation. The aim therefore of reducing extraneous load is to free working memory capacity for germane load – If the only result of a reduction in extraneous load is to reduce mental work, learning is not improved.

Current research in the field continues in the areas of measurement and evolution of cognitive load.

References

