# Cognitive Load Theory

## General

Cognitive load theory is a cognitivist learning theory introduced in mid-1980s by John Sweller, an Australian educational psychologist. The key aspect of this theory is the attention paid to the human cognitive architecture: characteristics and relations between long-term memory and **working memory**, and **how load on cognitive system affects learning**. Working memory is the critical part of this system since it enables new information to be assimilated into long-term memory. In Sweller's words,

- "*instructional designs that ignore working memory are likely to be random in their effectiveness*"[1].

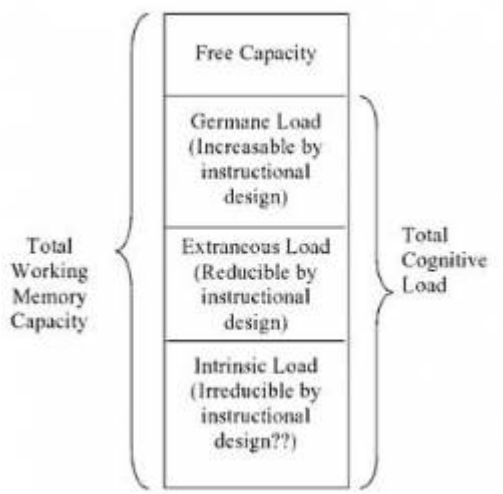
## What is cognitive load theory?

Sweller in his theory recognizes Information processing theory introduced in 1950s by George Miller and findings that human working memory has a very limited duration[2] and capacity of 7±2[3] or even as little as 4±1 elements[4]. This number is further reduced to just two or three if some manipulations with those elements have to be performed[5]. He suggests that there are evolutionary reasons for that and that such working memory could be even more efficient than a bigger one.[6]

Learning is according to Sweller an **alteration in the long-term memory**, which in humans has practically unlimited capacity[7]. That capacity is used to store knowledge in schematic forms, where **schemata**, according to Sweller represent

- "*cognitive constructs that incorporate multiple elements of information into a single element with a specific function*"[8].

Importance of the working memory in the learning process is that in order to reach long-term memory storage, information first has to be retrieved and processed by the working memory. After acquiring a new schema (verbal, pictorial, spoken or written[9]), it can be further extended and improved by practice and finally automated (for example operation of reading). If a schema is automated, conscious effort needed to perform a task related to it will be decreased.[10]




According to the cognitive load theory, during the process of learning, a cognitive load is imposed on the working memory. For learning to be efficient, the amount of cognitive load imposed must not exceed the capacity available. Cognitive load theory sugggests **three types of cognitive load**[11]:

| **Cognitive load types** | |
|---|---|
| **Germane cognitive load** | This type of cognitive load is caused by the learners own **effort to construct new schemata**. "*Effective instructional methods encourage learners to invest free processing resources to schema construction and automation, evoking germane cognitive load.*"[12]. |
| **Extraneous cognitive load** | This type of cognitive load is caused by **inappropriate instructional designs** that do not take into considerations mentioned limitations and architecture of human memory. Sweller and other researchers have proposed various methods for improving instructional design. Since most of them is oriented on learning from multimedia materials, they are listed and explained in the Cognitive theory of multimedia learning section. |
| **Intrinsic cognitive load** | This type of cognitive load is caused by element interactivity or inherent complexity of the information which needs to be processed. For example, when translating a number of words intrinsic cognitive load is quite small, but when translating same number of words forming part of a sentence intrinsic cognitive load is higher since not only meanings of individual words, but also their relations must be analyzed. Newly suggested techniques to reduce intrinsic load include simple to complex ordering or molar instead of modular presentations.[13]. |

Cognitive load types are **additive**.[14] That means the reduction of extraneous cognitive load may allow an increase in germane cognitive load. Also, if intrinsic cognitive load is rather low (information to learn is not complicated), it can be learned even though extraneous cognitive load is rather high (learning material is badly designed).

One of the problems related to cognitive load theory is **measuring** of cognitive load. The most commonly used method is a one item questionnaire. In the original questionnaire introduced by Fred Paas in which learners mark their "*perceived amount of mental effort*" on a 1 to 9 scale with extreme values labeled "*very, very low mental effort*" and "*very, very high mental effort*".[15] This is the most common way of measuring cognitive load, yet there is no standard form of questionnaire, nor labels or scale range, which makes results difficult to compare. Other methods include neuro-imaging techniques or physiological measures like heart rate variability or introducing a secondary task while learning, yet non of these provided satisfying results[16].

## What is the practical meaning of cognitive load theory?

Key concepts of Sweller's theory are human working memory characteristics which have to be considered during instructional design in order to free as much capacity for learning as possible. That will reduce cognitive load overall or enable increase in learners germane cognitive load. Both ways it should enable more successful learning.

Various ways of reducing extraneous cognitive load have been suggested so far. Since they mostly origin from same roots as the cognitive theory of multimedia learning, they are summarized and explained in cognitive theory of multimedia learning section.

Aside from reducing extraneous load, learners should be encouraged to increase their germane load, which can be achieved with help of learning scaffolds, questions reminding them on the just learned content and practice materials. Instructional approaches successfully increasing germane load have shown to enhance learning[17].

# Criticisms

Although cognitive load theory is at this time one of the dominant learning theories, it is still criticized for a number of reasons. Conceptual problems with cognitive load theory include[18]:

- **Post-hoc explanations** - "*the fact that cognitive load is composed of three different elements that are "good" (germane), "bad" (extraneous), or just there (intrinsic) means that every outcome fits within the theory post-hoc.*"[19]
- **Doubtable additivity** - Ton de Jong[20] also claims that intrinsic cognitive load is by itself different from extraneous cognitive load (the first refers to cognitive processes and the second to learning material or representations) and therefore cannot be added to the overall cognitive load. This claim is supported by Moreno[21].
- **Lack of precision** in describing concepts such as **cognitive load**, **mental load**, and **mental effort**[22],
- **Problems in definitions** of each type of cognitive load[23].

Methodological problems with cognitive load theory include[24]:

- There is no reliable method for **measuring cognitive load**
- Limited **value of experiments** since most of them were conducted in laboratories and include "*participants who have no specific interest in learning the domain involved and who are also given a very short study time*"[25]. Often the results were not so supportive in real classroom settings.
- Does not take into consideration **newer cognitive research** or attempt to explain role of working memory in learning.

# Keywords and most important names

- **Cognitive load theory**, **long-term memory**, **working theory**, **information processing theory**, **schema**, **extraneous cognitive load**, **intrinsic cognitive load**, **germane cognitive load**

- John Sweller, George Miller, Fred Paas

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## Read more

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