COGNITIVE LOAD THEORY

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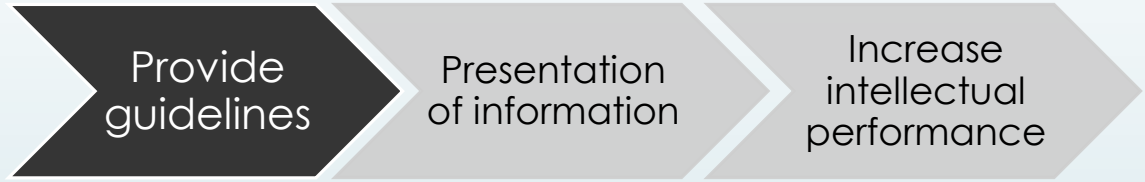
Definition

- In cognitive psychology, **cognitive load** refers to the used amount of working memory resources.
- "Cognitive load theory has been designed to provide guidelines intended to assist in the presentation of information in a manner that encourages learner activities that optimize intellectual performance“



- The fundamental tenet of cognitive load theory is that the **quality of instructional design** will be raised if greater consideration is given to
  - the role of working memory and
  - limitations of working memory.

- Instructional designers **control the conditions** of learning within an environment,
  - within instruction materials
  - Decrease extraneous cognitive load during learning
  - Refocus learner’s attention towards germane material (schema), i.e. increasing germane cognitive load.

Types of cognitive load

- **Intrinsic cognitive load** is the inherent level of difficulty associated with a specific instructional topic
- all instructions have an inherent difficulty level.
- e.g., the calculation of 2 + 2, versus solving a quadratic equation.
- This inherent difficulty may not be altered by an instructor.
- However, many schemas may be broken into individual "subschemas" and taught in isolation, to be later brought back together and described as a combined whole.

- **Extraneous cognitive load** refers to the way information or tasks are presented to a learner
- Because there is a single limited cognitive resource used to process the extraneous load, the number of resources available to process the intrinsic load and germane load (i.e. learning) is reduced.
- e.g., explaining the shape of any object, (telling it verbally or show its picture)
- This inherent difficulty can be altered by an instructor.
- when intrinsic and/or germane load is high (i.e., when a problem is difficult), materials should be designed so as to reduce the extraneous load.

- **Germane cognitive load** is the processing, construction and automation of schemas.
- e.g., while understanding new formula or knowledge by associating it with previous concept in mind, previous schemas are more active.
- This load can be controlled by an instructor.
- It is suggested that instructor should limit extraneous load and promote germane load.

History of CLT

- The history of cognitive load theory can be traced to the beginning of cognitive science in the **1950s** and the work of **G.A. Miller**.

- In his classic paper, Miller (1956) was perhaps the first to suggest our **working memory capacity has inherent limits**. His experimental results suggested that humans are generally able to hold only **seven plus or minus two units** of information in short-term memory.

- in the early **1970s**, **Simon and Chase** (1973) were the **first to use the term "chunk"** to describe how people might **organize information in short-term memory**. This chunking of memory components has also been described as **schema construction**.

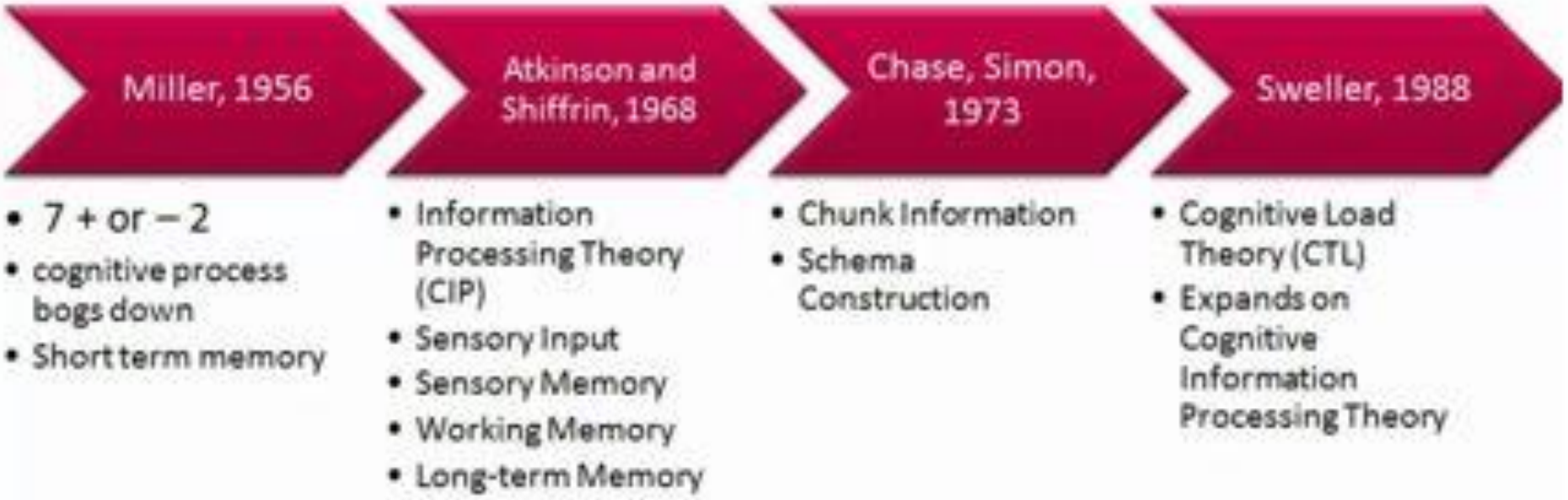
History cont…

- In the late **1980s**, **John Sweller**(1988) **developed cognitive load theory (CLT) while studying problem solving.** Studying learners as they solved problems, he and his associates found that learners often use a problem solving strategy called **means-ends analysis**. He suggests **problem solving by means-ends analysis requires a relatively large amount of cognitive processing capacity, which may not be devoted to schema construction.**

- Sweller suggests that **instructional designers should prevent this unnecessary cognitive load by designing instructional materials which do not involve problem solving**. Examples of alternative instructional materials include what are known as worked-examples and goal-free problems.

- In the **1990s**, cognitive load theory was applied in several contexts. The empirical results from these studies led to the demonstration of several learning effects. the completion-problem effect, modality effect, split-attention effect, worked-example effect and expertise reversal effect.

Cognitive Load Theory …



Research implications of CLT

- **Topic selection**, learning, instruction methods, performance, academic achievement, motivation, self regulation, multimedia learning, problem solving, learning difficulty, attention, reaction time.
- Literature review
- Hypotheses formulation
- Research design, mostly true experimental studies.
- Data collection/measurement of CL,
- Data analysis. Mainly include pre-test and post-test conditions, and related analysis measuring groups, like ANOVA paired sample t-test etc.

Literature review

- Adams, E. J., Nguyen, A. T., & Cowan, N. (2018) showed how theories of working memory can be organized according to their stances on 3 major issues that distinguish them: **modularity** (on a continuum from domain-general to very modular), **attention** (on a continuum from automatic to completely attention demanding), and **purpose** (on a continuum from idiographic, or concerned with individual differences, to nomothetic, or concerned with group norms).
- Another meta analysis review was conducted by Kirschner, P. (2002) which consists of six articles from four countries and three continents on the instructional implications of CLT.

Measurement of CL

- Paas and Van Merriënboer (2016) developed a construct (known as **relative condition efficiency**) which helps researchers **measure perceived mental effort**, an index of cognitive load.
- This construct provides a relatively simple means of comparing instructional conditions. **It combines mental effort ratings with performance scores.** Group mean z-scores are graphed and may be compared with a one-way ANOVA
- Paas and Van Merriënboer used relative condition efficiency **to compare three instructional conditions** (worked examples, completion problems, and discovery practice).
- They found **learners who studied worked examples were the most efficient, followed by those who used the problem completion strategy.** Since this early study, many other researchers have used this and other constructs to measure cognitive load as it relates to learning and instruction. (Pass et al, 2003)

Measurement of CL

- The **ergonomic approach** seeks a quantitative neurophysiological expression of cognitive load which can be measured **using common instruments, for example using the heart rate and blood pressure as a measure of both cognitive and physical occupational workload.(Fredricks et al, 2005)** they believe that it may be possible to use RPP measures to set limits on workloads and for establishing work allowance.
- **Task-invoked pupillary response** is a form of measurement that **directly reflects the cognitive load on working memory**.
- **Greater pupil dilation** is found to be associated with **high cognitive load. Pupil constriction** occurs when there is **low cognitive load**. **(**Granholm, 1996**)**
- Task-invoked pupillary response shows a direct correlation with working memory, making it an effective measurement of cognitive load explicitly unrelated to learning.
- Some researchers have compared different measures of cognitive load. For example, Deleeuw and Mayer (2008) compared three commonly used measures of cognitive load and found that they responded in different ways to extraneous, intrinsic, and germane load.

Measurement of CL

Table 2

Three Ways of Measuring Cognitive Load in Multimedia Learning

Type of measure	Implementation of measure
Response time to secondary task	At each of eight points in an animated narration, the background color slowly changes from pink to black, and the learner's task is to press the spacebar as soon as the background color changes.
Effort rating	At each of eight points in an animated narration the learner is asked to rate "your level of mental effort on this part of the lesson" on a 9-point scale ranging from 1 (*extremely low mental effort*) to 9 (*extremely high mental effort*).
Difficulty rating	At the end of the lesson, the learner is asked to rate "how difficult this lesson was" on a 9-point scale ranging from 1 (*extremely easy*) to 9 (*extremely difficult*).

Applications of CLT

- Theoretical applications
- Classroom implications
- Technological implications
- Applications for Instructors/teachers
- Role of technological distractions

Theoretical application

- The theory was used to hypothesize that some conventionally used instructional designs are inadequate. It also was used to design alternative modes of instruction predicted to be more effective.
- The ultimate aim of any theory dealing with cognition and instruction must be that it generates new and useful instructional techniques

Classroom implications

- The goal of the instructor should be to **reduce extraneous cognitive load and increase germane cognitive load to improve learning.** Instructors can accomplish this in a variety of ways:
- 1. **Change problem solving methods** to avoid means-ends approaches that impose a heavy working memory load by using goal-free problems or worked examples.
- 2. **Physically integrate multiple sources** of information whenever possible to eliminate the need for learners to have to mentally integrate that information which increases the load on working memory.
- 3. **Reduce repetitive information** whenever possible so that the load on working memory is lessened.
- 4. **Use auditory and visual information** under conditions where both sources of information are essential (i.e. non-redundant) to understanding. This helps increase the capacity of working memory.

Technological Application

- The Cognitive Load Theory can be implemented into the technologically-enabled classroom in many ways.
- Power Points are a great way to provide graphics and text together, while computer activities can provide worked examples and practice.
- Other ways also help to reduce cognitive load include.
  - graphical representation of data
  - making flowcharts
  - diagrams,
  - Tabular representation etc.

Application for instructors/teachers

- Technology can reduce the effort devoted to tedious computations and increase students' focus on more important mathematics.
- Two elements of successful integrations:
- Focusing Student Thinking
  - More realistic or important problems.
  - Exploration and sense- making with multiple representations.
  - Development of flexible strategies.
- Making Ideas Tangible
  - Build upon students' prior knowledge and skills.
  - Emphasize the connections among mathematical concepts.
  - Connect abstractions to real-world settings.
  - Address common misunderstandings.

Role of technological distractions

- While technology can be helpful, due to the idea of extraneous cognitive load it may also be a **distraction**.
- **the Coherence Effect:** peoples' learning is hindered when extraneous sound, pictures, and words are used in teaching.
  - instructors should avoid using distracting pictures or sounds in PowerPoint presentations.
- **the Modality Effect:** people learn better when words are presented as speech rather than on-screen text.
  - teachers should not rely solely on technology such as a computer screen or a PowerPoint to provide information.

Conclusion

- cognitive load theory (CLT) can provide guidelines to assist in the presentation of information in a manner that encourages learner activities that optimise intellectual performance.
- It is based on a cognitive architecture that consists of a limited working memory, with partly independent processing units for visual and audio information, which interacts with an unlimited long-term memory.
- According to the theory, the limitations of working memory can be circumvented by coding multiple elements of information as one element in cognitive schemata, by automating rules, and by using more than one presentation modality. (Kirschner, P., 2002)

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THANK YOU

QUERIES?