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Pedagogy Quick Read

# Designing Multimedia for Clarity

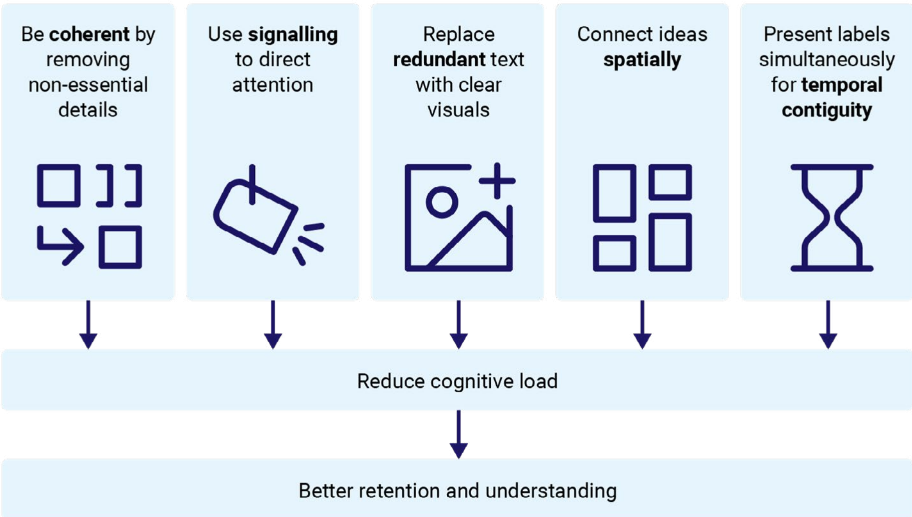
Mayer's Principles of Multimedia Learning, developed from the Cognitive Theory of Multimedia Learning (CTML)[1], offer a research-informed framework for designing effective teaching materials. When applied to computing education, these principles help reduce unnecessary cognitive load — the mental effort unrelated to learning. This means learners can dedicate more working memory to essential and relevant processing, supporting the development of accurate and lasting understanding of computing concepts.


## Summary

Mayer identifies five key principles that help reduce extraneous processing in multimedia learning[1]. These are particularly relevant in computing, where learners must interpret visuals and text, including code, at the same time. This challenge can be intensified for multilingual learners, as additional linguistic processing increases cognitive load. Applying these principles helps learners focus on essential information, improving understanding and retention.

- **Coherence Principle:** Include only elements essential to the learning objective[2]. Remove non-essential words, graphics, sounds, and irrelevant details[3].
- **Signalling Principle:** Use visual or auditory cues, such as arrows, bolding text, colours or vocal emphasis, to direct attention to key parts of the material[4].
- **Redundancy Principle:** Avoid presenting identical information in multiple forms. Replace dense text slides with clear visuals and spoken explanations[3].
- **Spatial Contiguity Principle:** Place related words and visuals close together to reduce split-attention[5].
- **Temporal Contiguity Principle:** Present related words and visuals simultaneously, aligning narration with visual elements[2].

Together, these principles help computing educators design clear explanations and resources that lower unnecessary cognitive load and make core ideas easier for learners to understand.


5 of Mayer's principles that promote clarity and thereby support learning

## Coherence

The coherence principle encourages educators to focus only on the material that directly supports the learning goal[2]. When teaching computing, this means focusing on the key constructs that learners must understand, and removing anything that distracts from those essentials.

Eliminate non-essential words, graphics, and sounds that do not reinforce the concept[3]. Avoid "seductive details", which is information that is interesting but irrelevant, as they divert learners' limited working memory away from core ideas. This includes additions such as decorative imagery or unnecessary narrative context that does not support the concept being taught, such as interesting facts or historical references.

In practical terms, keep videos and slides free of decorative elements or tangential commentary. A focused explanation of the computing concept is more valuable than background music or other content which may increase learner processing. By streamlining materials to contain only essential content, educators can reduce extraneous processing and help learners apply their cognitive resources to genuine understanding[1].

## Signalling

The signalling principle highlights the value of guiding learners' attention to what matters most. By adding clear visual or auditory cues, educators can help learners identify key ideas and understand how information is organised.

Use arrows, bold or coloured text, cursor movements, and other uses of colour to focus attention on crucial parts of a diagram or model[3]. For example, when teaching a simple network diagram, arrows can be used to show the direction data travels, while verbal emphasis or gestures draw attention to the device or connection currently being discussed[6]. When introducing a new piece of information, such as a stage in the Input–Process–Output (IPO) cycle or a component of a computer system, link it to a familiar idea so learners can recognise patterns and meaning more quickly[4]. In programming, sub-goal labelling can also act as a form of signalling by marking the purpose of each stage in a process, helping learners see where one meaningful step ends and the next begins.

Using signalling consistently across a sequence of lessons or resources helps learners build familiarity, reducing the effort needed to work out where to focus their attention. Effective signalling reduces confusion about where to look or what to prioritise.

## Redundancy

The redundancy principle advises against presenting identical information in multiple forms at once[3]. When learners are presented with standalone text alongside a diagram containing the same information, they must compare and reconcile both inputs. This is an unnecessary mental effort that adds to unnecessary cognitive load.

Instead, aim to complement rather than duplicate information. Avoid narrating on-screen text word for word. Replace dense text slides with clear visuals and spoken explanations that elaborate on, rather than repeat, the visual content.

In computing education, this principle also applies when explaining network models or system processes. For example, when presenting the IPO cycle, keep the diagram visible while narrating how data moves through each stage, rather than reading the labels verbatim. By reducing redundant input, educators free learners to process relationships and flow within the system, rather than juggling multiple identical sources of information[1].

## Temporal contiguity

The temporal contiguity principle states that related words and visuals should be presented at the same time, not one after another[3]. When narration, visuals, or labels are out of sync, learners must try to recall earlier information while processing new input, which increases cognitive strain and distracts from understanding.

To support effective learning, align spoken explanations precisely with the visual elements they describe[2]. In slide decks, labelled objects introduced through animation should appear as a single, unified element. Avoid revealing labels and visuals in disconnected stages. When modelling a sequential process, explain each step as it appears, rather than showing all the visuals first and describing them later[5].

Synchronising explanation, imagery, and labels allows learners to connect what they see with what they hear in real time.

## Spatial contiguity

The spatial contiguity principle states that related words and visuals should appear close together[5]. When text and images are separated, learners must split their attention between multiple sources, increasing cognitive load and reducing comprehension.

In teaching computing, this means placing explanations directly beside the relevant diagram, interface elements or code segment. Avoid layouts that force learners to search across slides or screens to connect text with visuals, as even small distances can disrupt understanding by requiring additional effort to match related information. Positioning text labels, annotations, or brief descriptions adjacent to what they describe helps learners process words and visuals as a single unit, reducing the "split-attention effect"[5] and enabling them to focus more effectively on the logic and relationships within programming examples.

Mayer's principles offer a practical guide for reducing unnecessary cognitive load, with each principle supporting learning in a different way. In practice, not all of the principles will apply in every context, and there may be occasions where they conflict with other teaching priorities. Used well, they should inform design choices, helping you decide what is most appropriate for your learners and materials.

## References

[1]Mayer, R.E. (2011). Applying the science of learning to multimedia instruction. the-cc.io/qr32_1

[2]Pantazes, T. (2021) Online Instructors' Use of the Cognitive Theory of Multimedia Learning Design Principles: A Mixed Methods Investigation. the-cc.io/qr32_2

[3]Castro-Alonso, J.C., de Koning, B.B., Fiorella, L. et al. (2021) Five Strategies for Optimizing Instructional Materials: Instructor- and Learner-Managed Cognitive Load. the-cc.io/qr32_3

[4]Beck, L. &. Chizhik, A. (2013). Cooperative learning instructional methods for CS1: Design, implementation, and evaluation. the-cc.io/qr32_4

[5]Ginns, P. (2006) Integrating information: A meta-analysis of the spatial contiguity and temporal contiguity effects. the-cc.io/qr32_5

[6]Sands, P. (2019) "Addressing cognitive load in the computer science classroom. the-cc.io/qr32_6



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