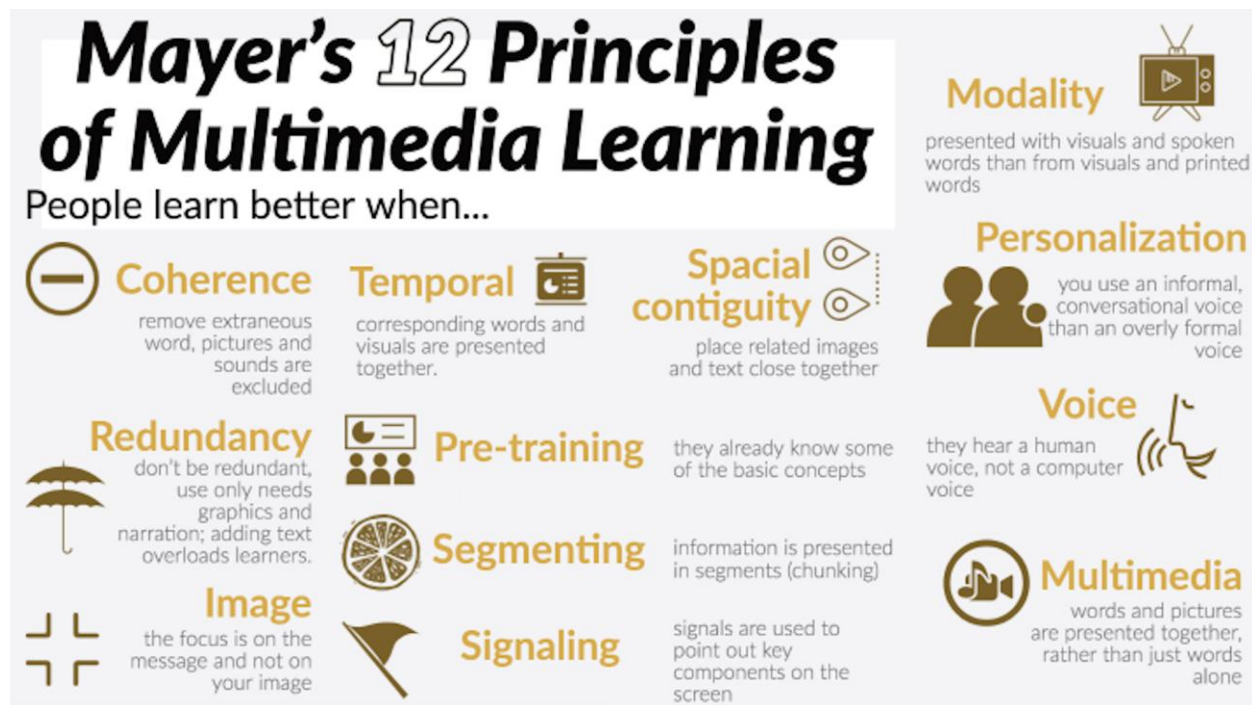


# Supplemental Material

*CBE—Life Sciences Education*

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**Supplemental Figure 1. Mayer's 12 Principles of Multimedia Learning.** The production of video content, including the style and format, can be informed by cognitive multimedia learning psychology to benefit learning outcomes. Visual images, in combination with verbal instruction, significantly increase recall and retention (R. E. Mayer, 2014). Cognitive psychologists, particularly Mayer et al., have identified effective practices in multimedia learning (Brame, 2016; R. E. Mayer & Estrella, 2014; R. Mayer & Pilegard, 2014; Quitadamo & Brown, 2001). In Mayer 2001, 12 principles for effective multimedia design are established (Figure 1). Multimedia design principles are easy to implement and have demonstrated improved for short-term retention (Issa et al., 2011). When educators begin the production process, they should acknowledge Mayer's principles and evaluate total cognitive load and examine the viewer's overall cognitive architecture. Cognitive load theory states that working memory (as opposed to long-term memory) can hold and process a certain amount of information at any given time (R. Mayer & Pilegard, 2014). The overload of this cognitive capacity is referred to as "essential overload," and should be highly considered in educational video production.

Before starting to create video content in pre-production, creators should observe Mayer's principles and think about eliminating extraneous information based on the desired learning objective. This is known as the coherence principle. The addition of extraneous or unnecessary information can exceed cognitive function and decrease learning outcomes. To prevent essential overload, some guidelines to follow during pre-production and production include: using familiar names and terms (pre-training principle), speaking instead of using on-screen text (modality principle), and combining narration with animation simultaneously (redundancy principle). Before deciding on video style, educators should be open to various formats and think creatively about their content delivery. Additional cognitive psychology principles to keep in mind before pre-production would be how to engage the audience, particularly with voice (voice principle) and by using a more conversational speaking style (personalization principle). During the post-production phase, many elements can be considered to improve learning outcomes from lecture videos using other types of social cues. For example, video can have learner-paced segments (segmenting principle), use cues to highlight essential information (signaling

principle), and organize words and pictures to be proximal both in space (spatial contiguity principle) and in time (temporal contiguity principle). By minimizing essential overload, the creator is eliminating extraneous processing to help the viewer grasp the main intention of the video (R. E. Mayer & Estrella, 2014; R. Mayer & Pilegard, 2014; Paas & Sweller, 2014).