

Improving Learning by Reducing Unnecessary Mental Load

(This document is the compiled and edited product of the students in Carl Wieman's 2014 Stanford course in Science Teaching and Learning, with special thanks to Jennifer Crosby)

The portion of the memory that remembers and processes new information on short time scales (the "short term working memory") has a very limited capacity. Many studies have shown that anything that adds demands on working memory ("cognitive load") that is not essential for the desired learning will reduce that learning (Mayer and Moreno 2003, Mayer et al., 2008). Thus everything presented to the learner has a cost, even artistic background graphics and peripheral interesting facts or stories ("seductive details").

Below is a list of strategies for reducing unnecessary cognitive load to enhance learning during class (compiled by students based on their experiences):

Lecture organization:

- Provide an explicit organizational structure or outline, and revisit it during the lecture (the organization is always much less obvious to a novice student than it is to the instructor)
- Use a chronology or slide progression that makes logical sense
- Convey one message per slide, summarized in the title
- Slides should make sense on their own as much as possible
- Explicitly link new material to prior topics
- Make clear delineations and transitions between topics
- Organize topics into chunks with lecture breaks (such as problems or activities designed to use or solidify information just presented) between chunks
- Avoid peripheral information and seductive details. Find ways to make material interesting that is directly linked to the desired learning objectives.
- Reduce jargon to absolute minimum
- Introduce and define any necessary new terms explicitly, and do not assume they will be remembered when seen later—give reminders
- Arrange for learning of simpler components, such as new terms and characteristics, to happen prior to lecture (e.g. pre-reading assignment with quiz)
- Accompany complex ideas with additional diagrams and/or analogies

Slides and visuals:

- Slides should be visually clean and concise with simple fonts and backgrounds
- Use high contrast between slides and backgrounds
- Use bullet points with short phrases rather than complete sentences
- Avoid large blocks of text
- Avoid figures and pictures that are purely for visual appearances; everything should be directly relevant to ideas to be conveyed
- Avoid figures with extensive text and details that are not essential
- Include titles and labels for all figures
- When using a figure, highlight important takeaway messages
- Emphasize important points visually by bold text, large font, and/or colors.
- Be willing to modify graphics from the Internet - the creators' design is not necessarily educationally optimal
- Use animations to step through the slide as you talk about each point on the slide, rather than displaying large amounts of text all at once, which can split student's attention

- Avoid distracting animations that are irrelevant to objectives (text spiraling in, etc.)
- If there is a point in the presentation when the instructor wants to be talking or presenting something without a slide, include a blank slide in the presentation so student attention is not split between verbal input and unrelated visual input

Projected written notes (in addition to the items above listed for slides and organization):

- Scrolling through portrait-formatted notes onscreen often means important information will be missing on each screen – landscape format is better for projecting
- Handwritten notes are often difficult to read when projected -- type notes whenever possible, and if not possible, write large and carefully
- Lines on lined paper usually make reading difficult when scanned and projected

Classroom atmosphere and pace:

- Leave slides up long enough for students to absorb and/or record the information. Remember, this takes much longer when one is seeing them for the first time
- Solicit feedback on pacing
- Provide a skeleton framework for note taking
- Reduce potential distractions in the classroom atmosphere, such as temperature (too hot or cold), noise from outside, buzzing lights and fans, as well as things like difficult-to-read chalkboards and dry erase markers.

Suggested relevant mid-quarter evaluation questions:

- When I am lecturing, what do you usually look at or focus on?
- In general, are you able to read everything and understand what is on the slide?
- Do you feel you have enough time, too much time, or too little time process new information that is presented and take necessary notes?

The Two Conflicting Purposes of Lecture Slides

Instructors usually use same PowerPoint slides for two different purposes:

1. Presentation of the material
2. Lecture notes as a reference source for students' further study at home.

Designing slides to address these two purposes simultaneously comes at a price. If higher priority is given to lecture presentation, the slides may be too abbreviated to serve as good reference. If they are a good reference source, they likely will be too dense for optimum use in class. To avoid this conflict, instructors can make slides primarily for class and then include more text and details in the notes section of the slides or on additional slides that are not shown in class. Another solution is to create two sets of materials – one for class and one with more detail for later reference and, possibly, guidance to instructor during class but not shown to students.

References:

- R. Mayer and R. Moreno, "Nine Ways to Reduce Cognitive Load in Multimedia Learning," *Educational Psychologist*, 38(1), 43–52 (2003).
- R. Mayer, E. Griffith, I. Jurkowitz, and D. Rothman, "Increased Interestingness of Extraneous Details in a Multimedia Science Presentation Leads to Decreased Learning," *Journal of Experimental Psychology: Applied*, 14(4), 329–339 (2008).