2.2 Multimedia Principle for Reducing Extraneous or Ineffective Cognitive Load

Findings:

✓ **Multimedia Principle:** Based in the cognitive theory, generative learning occurs once students find meaning in the multimedia lesson, especially “when learners mentally construct connections between the words and the graphic presented in the lesson” (Colvin, & Mayer, 2016b, p. 76). The multimedia principle is one of the principles that has been well established in the literature, and it declares that “people learn more deeply from words and graphics than from words alone” (Colvin, & Mayer, 2016b, p.78).

- **Not all the graphics give the same benefits in the students’ learning.** In specific, decorative (Jeager, & Wiley, 2014) and representative graphics should be avoided since they do not provide important information in the learner’s cognitive process. On the other hand, graphics as organizational, transformational and interpretative (See. Figure 2) will help students’ understandings, as well as the lesson, should warranty the use of relational graphics when there is text in the multimedia presentation that is describing quantitative relationships (Colvin, & Mayer, 2016b).
  - The decorative images that are used to increase students’ interest, and do not help to understand concepts, presented in a learning environment, can potentially increase less-relevant heuristics cues since these decorative images are not connected on the process of creating a mental model of the text. It is also found that the decorative images increase the tendency for students to relay invalid cues, given the disconnected information. Additionally, it was found that these images can harm students “metacomprehension accuracy.” The metacomprehension accuracy is defined as “the ability of an individual to predict how well one will do on a set of a comprehension tests after reading a set of texts” (Jeager & Wiley, 2014, p.58).

- **Videos can also be applied to the multimedia principle:** The students learn better when in the presentation is included a video that gives examples regarding the lesson, rather than reading it in a text-based description (Colvin, & Mayer, 2016b, p. 79).

- **Graphics may help more low-knowledge learners than high-knowledge learners:**
  - The effect that graphics have in more expert students can be counterproductive in most of the cases, and it is defined as **“Expertise reversal effect.”** The expertise effect is the interaction between diverse instructional methods and the student level of expertise or their prior knowledge. Essentially, this effect is produced because of the limited capacity of the working memory has on handling new information. The human cognition treats this information by encapsulating many elements in ‘higher-level chunks’ over the time and practice. The concepts and information become in an organized knowledge that expert students use information in more automatic mode. A difference to the simultaneous cognitive process of the novice students, the more expert students have built a relevant base knowledge that they will need to “reconcile and co-refer” (Kalyouga, 2012, p. 68) with the newly provided information. This can create a cognitive load that can “potentially reduce working memory resources available
for meaningful learning of new information”. Presenting detailed graphics and narration can potentially inhibit the expert students’ in their learning process (Kalyouga, 2012).

Redundancy Principle: “Do not add printed text to spoken text” (Mayer, 2014)

- Mayer (2001) mentions that not all of the techniques of redundancy functions have the same effectiveness. Considering that in multimedia explanations there are animations, narration, and on-screen text, the theory of redundancy will not work the same if you remove narration rather than the on-screen text. The reason for this is that if the narration is removed, it will contribute to the split attention in the student; contrastingly, if the on-screen text is removed instead of narration, the benefits will be greater (Mayer, E., Heiser, J. & Steve, L., 2001,196).

- The study also indicates that “interesting words”, or words that draw learners’ attention, within the presentation and that included as in-video text led to poorer recall on a test if they were not relevant to the content. Similarly, adding video clips that are attractive but irrelevant to the concept presented in the multimedia have negative effect on the students (Mayer, E., Heiser, J. & Steve, L., 2001).

Coherence Principle: “Eliminates extraneous materials” (Mayer, 2014). This principle indicates that people learn more deeply when, in the multimedia message, extraneous materials are excluded, rather than when extraneous materials are included in the instructional design (Colvin, & Mayer, 2016).

Signaling Principle: “Highlight essential material” (Mayer, 2014) This principle indicates that people learn more deeply when cues are added to the instructional material. It provides organization for essential information that guides learners (Colvin, & Mayer, 2016).

- To understand why the signaling principle works, it is imperative to explore concepts of contextual cueing (see 2.3).

- The repeated objects in the same location in a multimedia instrument create a predictable visual scene, which helps to decrease the neural activity. The predictable apparition allows learners to recognize elements in a learning instrument easily and quickly (Cooney, 2014).

Spatial Contiguity or Split-Attention Principle: “Place printed text near corresponding graphic simultaneously”. This principle indicates that people learn better when the multimedia is designed with the corresponding pictures near to each other (Colvin, & Mayer, 2016).

Temporal Contiguity Principle: “Present narration and corresponding graphic simultaneously” (Mayer, 2014). This principle indicates that people learn better, when the animation and narration occur at the same time rather than successively (Colvin, & Mayer, 2016).

Instructional Designer Recommendations:

1. The studies suggested that adding on-screen text summaries in the presentation can “hurt student learning.” This finding supports the split attention principle that mentions the generation of cognitive load, due to excessive demand of information from visual and auditory channels.
Consequently, students who did not have on-screen text in their animation had significantly increased retention in the test, compared to students who had on-screen text. However, the multimedia presentation should also give the opportunity of choice to the learners as to whether they prefer on-screen text or just hearing the words in the narration (Mayer, E., Heiser, J. & Steve, L., 2001, p. 192).


3. **Consider the level of expertise of the students**, “while novice students benefit from worked examples, more experienced learners benefit from versions of problem-solving” (Kalyouga, 2012, p. 69).
Table 4.1. An Organizational Graphic of Graphic Types.
Adapted from Clark and Lyons, 2011.

<table>
<thead>
<tr>
<th>Graphic Type</th>
<th>Description</th>
<th>Examples</th>
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| Decorative   | Visuals added for aesthetic appeal or for humor | 1. The general in Figure 4.3  
2. A person riding a bicycle in a lesson on how a bicycle pump works |
| Representational | Visuals that illustrate the appearance of an object | 1. The screen capture in Figure 4.2  
2. A photograph of equipment |
| Organizational | Visuals that show qualitative relationships among content | 1. A matrix such as this table  
2. A tree diagram |
| Relational   | Visuals that summarize quantitative relationships | 1. A bar graph or pie chart  
2. A weather map with colors to represent temperatures |
| Transformational | Visuals that illustrate changes in time or over space | 1. An animated demonstration of a computer procedure  
2. A time-lapse animation of seed germination |
| Interpretive | Visuals that make intangible phenomena visible and concrete | 1. A series of diagrams with arrows that illustrate the flow of blood through the heart  
2. Pictures that show how data is transformed and transmitted through the Internet |

Figure 2 Organization of graphic types