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Implications of Designing Instructional Video Using Cognitive Theory of Multimedia Learning

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1. **Objectives**

Educational researchers have produced a significant body of empirical evidence on the use of dynamic audiovisual learning materials demonstrating that learners are more likely to gain deeper conceptual understanding of the content from video than from words alone (Mayer, 2002, 2003; Mayer & Moreno, 2002). A major assumption underlying this empirical work is that humans can construct a mental representation of the semantic meaning from either auditory or visual information alone, but when instruction is presented in both formats, each source provides complementary information that is relevant to learning (Baggett, 1984). However, cognitive researchers found that audiovisual materials require high levels of cognitive processing to synthesize the visual and auditory streams of information and to extract the semantics of the message (Homer, Plass, & Blake, 2008). Furthermore, the high level of the cognitive processes increases especially when students are novices in the knowledge domain and lack appropriate prior knowledge to guide their attention (Moreno, 2004; Sweller, 1999). These cognitive processes place higher cognitive load on student's cognitive system due to the continuance stream of learning content, which may divert the limited cognitive resources available for processing the relevant materials of the lesson and as a result, learning and problem solving may be impaired (Chandler & Sweller, 1991). To overcome the limitations associated with learning from the audiovisual materials, cognitive researchers focused on developing and evaluating a number of design principles applied individually to various multimedia learning materials, such as to animations, interactive presentations, hypermedia, educational games, and effectively improved students' knowledge acquisitions (Mayer & Chandler, 2001; Mayer & Moreno, 2003). However, little research has examined the effects of these design principles in the context of educational video or when applied together. Therefore, the purpose of the present study was to explore the implications of applying three design principles as integrated design model to instructional video: segmentation, signaling and weeding (SSW model).

2. Theoretical Framework

The theoretical framework of this study based on cognitive theory of multimedia learning (CTML), which is suitable for the explanation of instructional manipulations on students' learning outcomes in the context of learning from educational video. CTML researchers developed many design principles through the manipulation of characteristics of the audiovisual materials such as segmentation, signaling, weeding, modality, pretraining, spatial contiguity, redundancy, and temporal contiguity. This study included three design principles in the SSW model: the first principle is *segmentation* or the prescription to divide learning materials into short units and distributed over series of instructional events, such as topics or lessons and referred to as segments (Clark, Nguyen, & Sweller, 2006). In video, segments are chunks of dynamic visualizations that have an identifiable start and end point and which are distinguished by inserting pauses between different segments (R. Moreno, 2007; Spanjers, Van Gog, Van Merrienboer, & Wouters, 2011).

The second design principle is *signaling*. Learning materials designed using this principles help students focus on relevant content in audiovisuals through several methods: increasing the luminance of specific objects in a visual display (e.g., de Koning, Tabbers, Rikers, & Paas, 2007) or by adding an outline and headings indicated by underlining and spoken emphasis (Mayer, 2005). Although signals do not provide any substantive information, research found that people learn more deeply from audiovisuals when essential material is highlighted or cued (Mautone & Mayer, 2001; Meyer, 1975; Tversky, Heiser, Lozano, MacKenzie, & Morrison, 2008).

The third component of the SSW design model is *weeding* or removal of irrelevant content in order to reduce the negative cognitive effects of the extraneous materials in audiovisuals. Mayer & Moreno (2003) suggested that learning materials are better understood when they include fewer rather than many extraneous words, visuals, and sounds and found that students learn better from a concise summary that highlights the relevant words and pictures than from a longer version of the summary.

3. **Methodology**

This study used a quasi-experimental, between-subjects design to assess the effect of the instructional video designed based on the SSW model (independent variable) and students' knowledge acquisition represented by four dependent variables: 1) the perceived difficulty of the learning material, 2) conceptual knowledge acquisition, 3) structural knowledge acquisition, and

4) transfer of knowledge. Learners' prior knowledge was included in all statistical analyses as covariates.

4. **Materials**

Participants were 226 undergraduate students enrolled in an introductory entomology course. There were 110 students in the SSW model group and 116 students in the no-SSW group. Males totaled 132 (*58.4 percent*) and females 94 (*41.6 percent*). Average age was 20 years old ($SD = 3.08$), with mean years in college of 2.3 ($SD = 1.07$).

The video used is a professionally produced about insects, as well as another version of the same video designed by applying SSW model:

1. Breaking the video up into 5 segments (i.e., segmenting).
2. Creating introduction and summary for each segment (i.e., signaling).
3. Removing video fragments that were interesting but non-essential for students to understand the learning materials (i.e. weeding).

The paper-based materials consisted of a pre-test and post-test typed on 8.5 X 11 inch sheets of paper. The post-test included a one-question self-report of perceived video difficulty (cognitive load measure, a 20-question multiple-choice test covering all major concepts (conceptual knowledge measure), a 5-question multiple-choice test (knowledge transfer measure), and a 20-item sorting task to arrange the main concepts in distinct categories (structural knowledge measure).

5. **Results**

MANCOVA results revealed significant effect for SSW model condition, Wilks' Lambda = .84, $F(1,223) = 8.345$; $p < .01$, eta squared =. 16. These results confirmed the previous findings from cognitive science research and found that students who learned from SSW model video reported lower difficulty of the video and scored higher on retention, far transfer and structural knowledge measures compared to students in no-SSW group.

First, students in the SSW model group (*M*=31.20, *SD*=6.173) performed better on gaining overall knowledge compared to the no-SSW group and the difference between the groups was statistically significant, $F(1, 223) = 7.235$, $p = .008$). The results also showed an eta square of .031, indicates that the SSW model had an estimated main effect of 3.1% improvement in the overall knowledge for the participants in the SSW model group.

Second, students in the SSW model group scored higher on the retention test (*M*=15.83, *SD*=2.526) compared to the no-SSW group (*M*=14.74, *SD*=3.051) and the difference between both groups was statistically significant, $F(1, 223) = 7.477$, $p = .007$). The results produced an eta square of .032, indicating that the SSW model had an estimated main effect of 3.2% improvement in total retention of information for the participants in the SSW group.

Third, students in the SSW model group also scored higher on the knowledge transfer test (*M*=4.52, *SD*=.763) compared to the no-SSW group (*M*=3.97, *SD*=1.038) and the difference was statistically significant $F(1, 223) = 19.506$, $p<.001$). The results produced an eta square of .080, indicates that the SSW model had an estimated main effect of 8.0% improve in total transfer of knowledge for participants in the SSW group.

Finally, students in the SSW model group scored higher on the structural knowledge test (*M*=11.98, *SD*=2.442) compared to the no-SSW group (*M*=10.49, *SD*=3.144) and the difference between both groups was statistically significant, $F(1, 223) = 14.614$, $p<.001$). The results produced an eta square of .062, indicates that the SSW model had an estimated main effect of 6.2% improve in total structural knowledge for the participants in that group.

6. **Scientific or scholarly significance of the study or work**

The results from the present study support CTML previous research and the underlying assumption driven from it, which suggests that human mind, can only process small portions of large amounts of visual and auditory stimuli at one time. Moreover, results are consistent with the evidence that SSW design principles can improve learning and reduce the perceived learning difficulty for novice learners by focusing their attention on important aspects of the learning material, providing concise cues and summaries about relevant information, and guiding them to engage in processing only the essential information (Mautone & Mayer, 2001; Mayer & Moreno, 2003).

Taking prior research into account, this study suggests several important implications for the design of instructional video. The SSW model found to be an effective way to design instructional video in assisting novice learner to study about insect and promote higher-level learning (i.e. transfer and structural knowledge). So far similar effect has been inferred mainly based on the effect of individual design principles on learning and with different multimedia learning materials such as animation and audiovisual static presentations. Results of the present study suggest that the same effect can be demonstrated with instructional video, providing convergent validity for the underlying effect of the CTML design principles.

The variation of students' learning outcomes in the SSW model group suggests that each design principle has its unique effect on the leaning goals and will likely facilitate certain learning outcomes and may lose its potency for others. For example, the results show that students in SSW group gained the highest scores in the transfer of knowledge and structural knowledge measures (as compared to knowledge retention), suggesting that SSW principles promote higher-level learning (Mayer, 2005). Therefore, instructional video designers must consider the relation between the learning outcome and the design principles used in video. For example, the segmenting principle may be most beneficial in terms of scaffolding structural knowledge acquisition, while signaling may prove more useful for helping learners integrate declarative knowledge. Consequently, educational video designers should have a very clear understanding of the learning goals and then design the video accordingly. This could be particularly useful in situations where there is little or no guidance from the instructor (e.g., online learning), or in face-to-face to explicitly focus and guide students on the essential concepts the video is designed to address.

Results of the present study are also consistent with prior CTML research in that adding irrelevant information to a multimedia presentation results in poorer understanding of the content (Mayer & Moreno, 2003). A possible explanation of this result is that in the non-SSW video condition, the nonessential information and the necessity to discern the most relevant content may have created extraneous cognitive load either by competing with the essential content for the limited cognitive resources or by demanding more cognitive resources to process the nonessential content. However, the SSW model helped students to organize their cognitive resources and process essential content more efficiently, leading to more deeper learning and, consequently, higher test scores.

Although the content of the video used in both groups was identical, students in the SSW model group reported that the video was significantly less difficult compared to students in the original video group. Consequently SSW model appears to be useful to decrease extraneous cognitive processing and enhance student learning from educational videos.

The use of concept-sorting task in the present study as a measure of structural knowledge acquisition has implication for learning outcomes measurement. While retention and transfer measures have traditionally been employed in prior studies to assess learning outcomes in multimedia learning, adding structural knowledge provides an important insight into learning from video.

Finally, applying the SSW model in this study to long video (32 minutes), suggests another practical implication. While prior studies employed shorter animation that varied from few second to few minutes, the long video used in this study may help students to adjust their metacognitive process to the new video design. It is conceivable that in such long treatment, participants were able to determine the pattern of the SSW video design and adapt to it, enhancing the probability of identification of the intervention effect. In a shorter treatment, however learners' metacognitive process might not have had the same noticeable effect due to the initial adjustment period it would require. This suggestion should be empirically tested.

References

Baggett, P. (1984). Role of temporal overlap of visual and auditory material in forming dual media associations. *Journal of Educational Psychology, 76*(3), 408-417.

Chandler, & Sweller. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*(4), 293 - 332.

Clark, Nguyen, & Sweller. (2006). *Efficiency in learning: Evidence-based guidelines to manage cognitive load*: Pfeiffer.

de Koning, B. B., Tabbers, H. K., Rikers, R. M., & Paas, F. (2007). Attention cueing as a means to enhance learning from an animation. *Applied Cognitive Psychology., 21*(6), 731-746.

Homer, B. D., Plass, J. L., & Blake, L. (2008). The effects of video on cognitive load and social presence in multimedia-learning. *Computers in Human Behavior, 24*(3), 786-797.

Mautone, & Mayer. (2001). Signaling as a cognitive guide in multimedia learning. *Journal of Educational Psychology., 93*(2), 377.

Mayer. (2002). *The promise of educational psychology : Learning in the content areas*. Upper Saddle River, N.J.: Merrill.

Mayer. (2003). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning and Instruction, 13*(2), 125.

Mayer. (2005). *The Cambridge handbook of multimedia learning*. Cambridge, U.K.; New York: Cambridge University Press.

Mayer, & Chandler. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology., 93*(2), 390.

Mayer, & Moreno. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review, 14*, 87-100.

Mayer, & Moreno. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43 - 52.

Meyer, B. (1975). *The organization of prose and its effects on memory*. Amsterdam; New York: North-Holland Pub. Co.; American Elsevier Pub. Co.

Moreno. (2004). Decreasing cognitive load for novice students: Effects of explanatory versus corrective feedback in discovery-based multimedia. *Instructional Science, 32*(1/2), 99-113.

Moreno, R. (2007). Optimising learning from animations by minimising cognitive load: Cognitive and affective consequences of signalling and segmentation methods. *Applied Cgnitive Psychology, 21*(6), 765-781.

Spanjers, I., Van Gog, T., Van Merrienboer, J., & Wouters, P. (2011). An expertise reversal effect of segmentation in learning from animated worked-out examples. *Computers in Human Behavior, 27*(1), 46-52.

Sweller. (1999). *Instructional design in technical areas*. Camberwell, Vic.: ACER Press.

Tversky, B., Heiser, J., Lozano, S., MacKenzie, R., & Morrison, J. (2008). Enriching animations. In K. Lowe & W. Schnotz (Eds.), *Learning with animation: Research and design implications*. New York: Cambridge University Press.