Chapter 48
A Research of Employing Cognitive Load Theory in Science Education via Web–Pages

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ABSTRACT

This study adopted Cognitive Load Theory (CLT) to investigate the influences of multimedia presentations on achievements of science learning and the correlations between eye-movement models under distinct multimedia combinations and learner-controlled modes. Three units from the Science Education Website set by the Ministry of Education (Tainan) to assist student learning were employed: Air and Combustion," "Heat Effects toward Substances," and "Healthy Diet." This multifunctional website offers teaching resources, interesting experiments, inquiry experiments, virtual animations, multi-assessments, and supplementary materials, which are highly interactive and simulative. Six classes of fifth graders (n=192) participated in this study. Our findings showed that the combination of multimedia elements apparently influenced students' performance; the "animation + narration" group performed evidently better than the "animation + subtitles" group. When the animated subject matters were in small segments under the Segmentation Principle, multimedia presentations still brought affections to learning achievement, suggesting that the modality effect on students' learning exists constantly. Regarding the eye-movement models, this study focused mainly on discussing the "active-control mode" and "multimedia combination forms." These eye movement data supplemented the evidences gained to identify the relevant results. In conclusion, inappropriate multimedia combinations may interfere with learning. More functions and information inputs do not guarantee better learning effects.

INTRODUCTION

In recent years, with constant renovation of the technology, the extent of its progress is great enough to cause a reformation to education. A number of teachers and experts are convinced that information technology can promote education reformation and infuse new ideas into the traditional teaching (Lin & Liu, 2007; Sun, Lin & Yu, 2008). Many previous studies suggested that the cognition and learning over scientific conceptions may be affected by special ability, operation in labs, and model-handling (Chuang & Liu, 2012; Lin & Atkinson, 2011; Liu, Lin, Liu, & Chang, 2012; Sun, Lin & Yu, 2008). These factors cannot be fully implemented via the current science teaching methods applied in the elementary schools. Therefore, technological back-ups are necessary for science teaching/learning. Likewise, the tendency of applying multimedia to academic areas is growing stronger (Sankey, 2003). Designers of the multimedia supplementary teaching materials integrate words, pictures, sounds, and animations to create interesting audio/video effects to attract students; the presentation styles from "nonstop playing" to "user-controlled playing" enable learners to control the learning pace according to personal interests and needs. However, are multimedia e-materials helpful to science learning? Suppose multimedia e-materials are helpful to science learning, then what is the best combination of multimedia elements for effective and efficient learning?

Cognitive Load Theory (CLT) holds that teaching designs should definitely take into consideration human cognitive structures and the possible limits which may take place when pursuing efficiency (Paas, Renkl, & Sweller, 2003). It further reveals different sources of working memory load (Jeroen, van Merrienboer & Sweller, 2005; Paas, Renkl & Sweller, 2003), including the complexity of the subject matters (intrinsic cognitive load), teaching designs (extraneous cognitive load), and the total effort (germane cognitive load)

made for learning. Germane cognitive load will appear when extra or excessive information such as detailed notes or reviews are given to students. While appropriate teaching designs are inadequate, additional extraneous cognitive load and a decline in learning will be resulted. The cognitive capacity limit of learners will be exceeded if the given information is strange, excessive, or bringing intrinsic cognitive load due to the complexity of teaching materials (Jeroen, van Merrienboer & Sweller, 2005). Thus, proper material presentation can not only diminish extraneous cognitive load but can also help learners concentrate on the subtleties of the subject matter, integration, and building up schemas. The correlations among three kinds of cognitive load are shown in Figure 1.

Abundant literatures show the impact on the combination of multimedia elements, cognitive load demanded and achievement made during the learning process. Many literatures indicate that combinations of multimedia e-materials create modality effect (Jeroen, van Merrienboer & Sweller, 2005; Liu, Lin, Liu, & Chang, 2012); that is, when different information processing channels (i.e. animation + narration) are triggered to sense the stimulation from multimedia, the learning effects are better than the ones from single processing channel (i.e. animation + subtitles).

Furthermore, Mayer (2001) brought up the dual-channel assumption-words are received through the verbal channel, while pictures are received through the visual channel. Different presentations are encoded through pictures or word formats. However, words are related to either printed or narrated text and can be processed via either verbal or visual channel. In addition, Mayer (2001) defined multimedia learning as building the mental model from materials that involve verbal and pictorial presentations. That is, the verbal presentations are related to spoken text like narration or written text in books, and the pictorial presentations are related to static and dynamic visualizations such as graphs, animations, etc (van Gog & Scheiter, 2010).

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