Multimedia Learning Principles and Instructional Design Among Teachers

A Pilot Study

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***Abstract*—An online survey of 112 educators who teach in a variety of K-adult settings explored the extent to which teachers understand and implement two Cognitive Theory of Multimedia design principles known to reduce extraneous cognitive processing into their electronic slide presentation (ESP) designs. Results indicate that although educators regularly design their own slide decks, most participants have low knowledge of how or why they should design coherent slide decks that do not include redundant information. Results also show the instrument questions should be refined and clarified.**

Keywords*—*Electronic Slide Presentations; Cognitive Load Theory; Cognitive Theory of Multimedia Learning; Coherence Principle; Redundancy Principle

I. INTRODUCTION

Teachers often create their own Technology-Enhanced Learning (TEL) materials [1]. PowerPoint® software is used extensively in both virtual and face-to-face learning environments [2][3]. It is possible that the quality of teacher-created TEL affects learning outcomes. Yet, it is unclear whether educators implement proven pedagogical practices in the design of instructional slides [4][5]. The application of the Cognitive Theory of Multimedia Learning (CTML) principles to Electronic Slide Presentations (ESP) has been proven to improve student learning in higher education [6]-[10].

The completion of a pilot study is no guarantee of the success of a main study, but it can result in improvement of the instrument [11]. This pilot was conducted to examine educators' understanding of and adherence to two evidence-based cognitive principles shown to mitigate extraneous mental processing (coherency and redundancy) in their design and use of ESP slides by seeking to answer: 1) To what extent do educators have a working knowledge of the CTML principles of coherency and redundancy? and 2) To what extent do educators apply the research-based multimedia principles of coherency and redundancy in their electronic slide design?

In this paper, the CTML theory and principles under investigation are briefly described in Section 2, and Section 3 explains the method and procedure. Results are reported in Section 4. Finally, conclusions and suggestions are presented in Section 5.

II. LITERATURE REVIEW

Mayer's development of the CTML principles grew out of Cognitive Load Theory (CLT), which is based in part on Working Memory (WM) theory [12]. New information (regulated by a central executive component) is perceived through the ears (phonological loop) and/or the eyes (visuospatial sketchpad) [13]. This model is a central tenet in both neuroscience and cognitive psychology [14].

CLT claims three types of cognitive load can interfere with learning: intrinsic, extraneous, and germane [15]. Intrinsic load is caused by the complexity of the information to be learned. The number of interacting elements dictates complexity, over which the instructor has no control [16]. However, the instructor can influence extraneous cognitive load, caused by items and activities that distract a learner from the task [17][18]. Germane cognitive load redistributes and mediates the cognitive load required to integrate new information into long-term memory [17].

Mayer applied the CLT model to multimedia learning and developed the idea that people learn more from both pictures and words than from words alone [17]. CTML currently proposes fifteen multimedia principles that instructors can use to improve learning [12]. This pilot study focused only on extraneous load. Within that category, only two multimedia principles were investigated: redundancy and coherence. The essential idea is to help people learn more deeply by presenting information in a way that does not cause the visual or auditory channels to compete for cognitive resources [17].

The redundancy principle implies people will learn more easily from a slide with a combination of graphics (visual) and narration (auditory) rather than a slide with graphics (visual), narration (auditory), and written text (both visual and auditory). If a learner's attention is divided between two things requiring visual processing (graphics and text), comprehension of both items is reduced [19]. Text on a slide identical in meaning to the narration is redundant and causes learner distraction [20]-[22].

The coherence principle states that people learn better when the information presented directly pertains to the topic [18]. Unrelated information causes distraction and reduces learners' ability to process new information. Moreno and Mayer [23] found that unrelated background music played simultaneously as narration caused competition in the audio channel of working memory and reduced learning.

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III. METHOD AND PROCEDURE

Descriptive data were collected through an exploratory web-based quantitative survey by contact with the researcher's schools, social media, and professional educational organizations. Through convenience and voluntary response sampling, educators were recruited as participants from a variety of virtual and face-to-face school settings in North America. The software Qualtrics® collected demographic data and Likert scaled responses concerning teacher knowledge and implementation of the coherence and redundancy principles to reduce extraneous cognitive load. Each research question was addressed three times. The software SPSS® (Statistical Package for Social Sciences) was used to analyze the results. Answers that positively reflected the principle were coded with a "1" and interpreted as high knowledge of the principle. Incorrect responses and I do not know responses were coded with "0" and interpreted as low knowledge of the principle.

Copyright-free images of possible ESP slide decks were included to assess knowledge of the principles. Figure 1 shows the two options for the coherence principle. The question was: "From which of the following two slides will student learn more deeply?" The slide option to the right contains an interesting but unnecessary graphic with extraneous text. Figure 2 shows the choices for the redundancy principle. The slide option to the right includes text redundant to the narration.

A separate group of questions assessed teacher implementation of the principles in ESP deck design. Participants responded to questions with four possible responses: Always, Most of the time, Sometimes, and Never. Answers that showed adherence to the practice of implementing the multimedia principle were coded "1," while those that did not indicate adherence to the principle were assigned a score of "0".

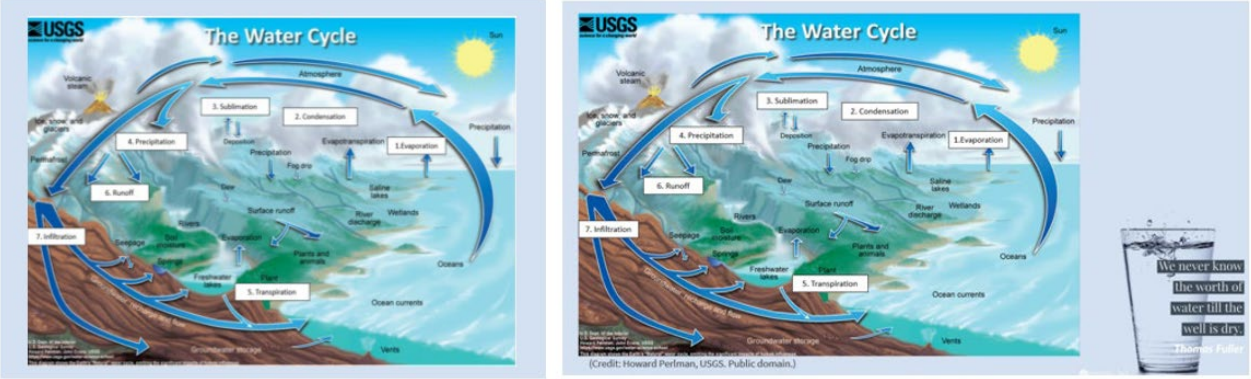

Figure 1. Knowledge of the coherence principle choices.

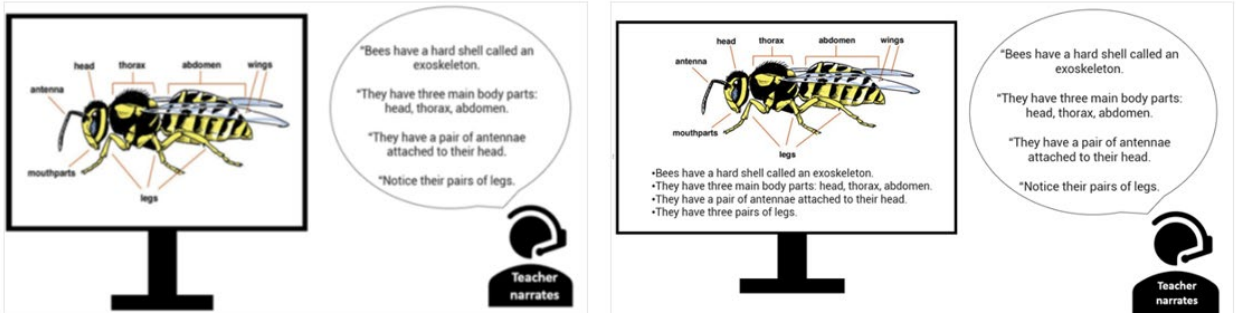

Figure 2. Knowledge of the redundancy principle choices.

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IV. RESULTS

Professional teachers (n = 112) who instruct students in different levels, environments, and content areas who use PowerPoint® or a similar presentation software tool (elementary school, n = 48; secondary school, n = 44; post-secondary school, n = 20) responded to the survey. The mean age of participants was 43.98 years, and the average of all respondents' teaching experience was 15.76 years. In all, 72 (64%) of participant educators used ESP software face-to-face in a brick-and-mortar classroom; 44 (39%) in an online asynchronous environment; and 64 (57%) used ESP software in distance, online, or virtual synchronous classrooms.

A. Knowledge Questions

Table 1 presents the responses to the coherence principle questions. Overall, participants appear to have inconsistent knowledge levels of this principle (M = .59, SD = .255). About half (n = 59, 53%) correctly identified the definition of the principle. A majority (n = 78, 78%) recognized that extraneous background music can be detrimental to comprehension, but only about one third (n = 43, 38%) drew the same conclusion about unnecessary graphics. Most participants, however, could identify a visual example of a more coherent slide (n = 86, 77%). Several respondents indicated they did not know the correct answers (34% for question 1; 21% for question 2; and 47% for question 3).

TABLE I. KNOWLEDGE OF COHERENCE

Knowledge of the Coherence Principle Questions			
Question	*Response*	*N*	*%*
Students learn better when interesting but extraneous graphics are excluded.	True	43	38%
	False	35	35%
	I do not know	34	34%
Students learn better when pleasant but unnecessary background sounds are included.	True	10	9%
	False	78	78%
	I do not know	24	21%
The coherence principle states to keep students' working memory from being overloaded, we should eliminate extraneous material from our presentations.	True	59	53%
	False	6	5%
	I do not know	47	42%
From which of the following slides will student learn more deeply? (Water cycle images)	Coherent image	86	77%
	Incoherent image	26	23%

Table 2 presents the responses to the redundancy questions. Fewer participants correctly identified the redundancy definition (n = 19, 17%) than the coherence definition. A slight majority (n = 68, 61%) recognized learning is improved when narration is conducted along with a graphic rather than printed text. About half of the participants chose the sample ESP slide with no redundant element (n = 57, 51%). A high proportion of participants indicated low knowledge by choosing "I do not know" as a response.

B. Adherence Questions

The data indicate that educators' slide design slightly adheres to the principle of redundancy (M = .52, SD = .315). However, two questions were criticized for assuming educators would show a slide with full paragraph of text. The first was "When showing a slide with a full paragraph or more of text, how often do you read the paragraph to the students?" and the other was, "When showing a slide with a full paragraph or more of text, how often do you give students time to read the paragraph in silence?" Therefore, those questions are not included. Only one question, "How often do you combine an image with a full paragraph or more of text?" (M = .71, SD = .457) is measured. Most participants (n = 79, 70.5%) were rated as having high adherence to the redundancy principle in this question.

TABLE II. KNOWLEDGE OF REDUNDANCY

Knowledge of the Redundancy Principle Questions			
Question	*Response*	*N*	*%*
Students learn better when a slide has all three elements: written text + graphics + teacher narration.	True	90	80%
	False	13	12%
	I do not know	9	8%
Students learn better when narration is accompanied by graphics rather than when the teacher narrates the printed text on the screen word-for-word.	True	68	61%
	False	19	17%
	I do not know	25	22%
The redundancy principle states presenters should not read their slides aloud because words we read are processed in both auditory and visual channels, which can cause students to comprehend less.	True	19	17%
	False	33	29.5%
	I do not know	60	53.6%
From which of the following slides will student learn more deeply? (Bee images)	Nonredundant image	57	51%
	Redundant image	55	49%

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V. CONCLUSION

Results of this pilot study reveal an inconsistent working knowledge of and adherence to the CTML principles of coherence and redundancy in educator ESP design. This lack of knowledge is concerning considering teachers are increasingly creating their own TEL materials, including slide presentations.

The large proportion of "I do not know" responses to knowledge questions may indicate a need for professional development. However, the data indicate some educators may be more intuitive about identifying higher quality slides without having explicit knowledge about definitions. It may be worthwhile to evaluate teacher-created slide decks and compare the results with teachers' perceptions of their adherence to the principles.

One purpose of this study was to gather information to develop a base of understanding about teacher practices before determining if applying CTML principles to ESP decks will improve student learning. Unfortunately, the results were limited because of unclear question wording and restricted answer options. Future studies should include clearer questions and use a Likert scaled response system.

Other suggestions for future research are to determine training requirements for virtual teachers, limit participation to K-12 virtual learning environments, for which there is a scarcity of studies, to investigate differences in terms of instruction for different age groups, and to expand the number of CTML principles to include contiguity and signaling, which are also used to reduce extraneous cognitive processing.

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