Examining Pre-service Chinese Teachers' Multimedia Design: A CTML-based Quantitative Study
(以多媒體學習認知觀點檢視職前中文教師多媒體課程設計)

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Abstract: This quantitative study observed 15 pre-service Chinese-as-a-second-language (CSL) teachers' skills at integrating digital multimedia into their online instruction, through the lens of Mayer's (2014) cognitive theory of multimedia learning. Specifically, it examined their use of multimedia applications, their prior knowledge of design principles, and the consistency of their course designs by analyzing lesson plans, course materials, and clips of teaching video. Most of the participants were found to have integrated digital multimedia into their instruction, in keeping with the signal-, coherence-, and spatial-contiguity principles of multimedia design. However, inconsistency and incoherence in their designs still presented a major stumbling-block to effective learning. This study contributes to a deeper understanding of how Chinese pre-service teachers can integrate multimedia into instruction, and recommends that Mayer's multimedia design principles be incorporated into CSL pre-service teacher training.

摘要：本研究以 Richard Mayer 的「多媒體學習認知」為理論基礎，檢測線上華語職前教師的多媒體輔助課堂的課件，探討其多媒體使用類型、多媒體教學設計之專業知能與穩定度。採量化研究，共分析 15 位遠距教師多媒體設計的課程教案、教材與教學影片。研究結果指出線上職前教師多數應用數位多媒體於課程設計，且教師的課件出現似強調原則、一致性原則、空間原則的設計現象。然而，這些課程設計現象並非穩定呈現，意味著教師的多媒體設計專業知能仍靠直覺並非專業多媒體設計知能的表現。此研究結果分析職前教師多媒體設計的現象，可作為培訓職前教師數位媒體設計之參考。

Keywords: Online instruction, Chinese as a Second Language teacher education, cognitive theory of multimedia learning, classroom-centered research

關鍵詞：多媒體輔助語言教學、教學設計、線上教學、華語師資培訓、課堂研究

1. Introduction

Teacher educators' instructional instincts and aesthetic preferences vary significantly, and this may result in some ineffectively designed teaching materials (Kalyuga, Chandler, & Sweller, 1999). According to Mayer (2009), students can learn more deeply when their instruction includes multimedia approaches. Based on numerous empirical studies, Mayer (2014) developed the cognitive theory of multimedia learning (CTML), which aims to explain how students learn from words and pictures, as well as how to design multimedia learning materials that promote meaningful learning. CTML holds that both theoretical and practical perspectives on instructional design can be used as points of reference when designing multimedia-enhanced learning materials and as guidelines for assessing pre-service teachers' knowledge of how digital multimedia can and should be used in instruction.

Other studies have indicated that many teachers, including Chinese-as-a-second-language (CSL) teachers, do not use technology in instruction or remain skeptical about such use (Chen, 2014; Galanouli & McNair, 2001; Sessoms, 2008). However, online field practices that take into account the specific characteristics of the technology-based teaching environment can maximize teachers' application of their knowledge of digital multimedia (Cheng, 2016). Thus, to closely investigate teachers' performance in the sphere of multimedia-enhanced language instruction, the present study examined how Taiwanese preservice CSL teachers used digital multimedia in delivering their online language-learning content, in light of Mayer's (2014) guidelines. Its research questions were as follows:

(1)   What forms of multimedia do Taiwanese pre-service CSL teachers use in their online lessons?

(2)   What are these teachers' levels of professional knowledge of multimedia learning principles (i.e., multimedia-, coherence-, signal-, and spatial-contiguity principles)?

(3)   How consistently are these multimedia learning principles reflected in these teachers' online lessons?

2. Literature Review

This section focuses on CTML and its application to second/foreign language (S/FL) learning, with the aim of establishing assessment guidelines for pre-service online teachers' knowledge of multimedia learning principles.

2.1 Theoretical Framework

Many instructional multimedia materials are designed based on designers' or instructors' intuition and aesthetic considerations rather than on any particular theory or the results of systematic empirical study (Kalyuga, Chandler, & Sweller, 1999). CTML

aims to elucidate how people learn from words and pictures, and thus how best to design multimedia learning environments that promote meaningful learning (Mayer, 2014). Rooted in a learner-centered, constructivist approach, it proposes that multimedia promotes cognitive activity during learning via three assumptions: dual-channel, limited-capacity, and active processing. Dual-channel processing is derived from Paivio's dual-coding theory (1986); limited-capacity from Baddeley's theory of working memory (1998); and active processing from Sweller's cognitive-load theory (2005). In other words, CTML posits that humans process information actively, via separate information-processing channels for verbal information (whether written/printed or spoken) and visual information. Each channel has limited processing capacity, and only a portion of the information it carries is retained in one's working memory; and multimedia materials should be compatible with how people learn.

When incorporating multimedia into lessons, increasing learners' cognitive activity without overloading their working memory is challenging. According to Mayer (2014), learning is associated with three types of information processing: extraneous, essential, and generative processing. The first, extraneous processing, refers to cognitive processing that does not support the instructional goal and is caused by poor design. The second, essential processing, aims to mentally represent the presented materials in working memory, and is triggered by the complexity of the material. Lastly, generative processing aims to make sense of the presented materials, and is closely associated with the learner's motivation to learn. Depending on the relationships of learners to their instructional situations, the levels of these three types of processing differ considerably, but their sum cannot exceed an indivudual learner's cognitive capacity. For cases where the learner's cognitive capacity is overloaded and instructional designs are ineffective, Mayer (2014) proposed instructional techniques that would minimize extraneous processing, manage essential processing, and foster generative processing. The present study investigated the multimedia designs that would be required to support these three aims, in light of Mayer's seven principles of processing.

Table 1: Seven Principles of Extraneous and Essential Processing

Goal	Principle
minimize extraneous processing	coherence principle
	signal principle
	redundancy principle
	spatial-contiguity principle
	temporal-contiguity principle
manage essential processing	modality principle
foster generative processing	multimedia principle

As shown in Table 1, the first five of these seven principles – coherence, signaling, redundancy, spatial contiguity, and temporal contiguity – all relate to reduction of the extraneous processing caused by poorly designed materials that do not accomplish their instructional objectives and may increase cognitive load.

1. Coherence principle. People learn more effectively when seductive details are excluded from the learning content. Extraneous messages such as unrelated graphics, background music, and unnecessary text should be removed to help learners focus on the relevant information.

2. Signal principle. Effective learning is also facilitated when the organization of multimedia content is highlighted via attention-grabbing cues. Such cues can be text-based (e.g., using numbering or a red font), picture-based (e.g., arrows or changing colors), or a combination of the two (e.g., text and corresponding pictures that change into the same color). As such, this principle is closely connected to the spatial-contiguity principle, discussed further below.

3. Redundancy principle. The presentation of the same information concurrently in multiple forms does not enhance learning. For example, people learn more deeply from graphics combined with narration than from graphics, narration, and on-screen text (Mayer, 2014). Redundant multimedia often consist of the same words occurring in both printed and spoken form, e.g., an audio message with identical printed text, or a narrated animation with onscreen text. This tends to increase the cognitive load placed on learners' working memory, and thus should be avoided. However, the same study by Mayer also indicated that the negative effects of redundancy may be diminished or even eliminated when learners are more experienced or knowledgeable and when the text is presented short without graphics in the content

4. Spatial-contiguity principle. Mayer (2014) maintained that "[p]eople learn more deeply from a multimedia message when corresponding words and pictures are presented near rather than far from each other on the page or screen" (p. 279): e.g., text placed adjacent to the corresponding part of a diagram, and diagrams with numbered captions. The same research by Mayer reported that this principle is robust even among learners with low levels of prior knowledge, particularly when the learning materials are complicated and/or interactive.

5. Temporal-contiguity principle. Mayer (2014) held that "[p]eople learn more deeply from a multimedia message when corresponding animation and narration are presented simultaneously rather than successively" (p. 279). He added that these temporal-contiguity effects are especially marked among high-spatial learners when a presentation is system-controlled and the information it contains is long and complex.

Essential processing refers to the cognitive process evoked to mentally present the messages a person receives in their working memory, due to the complexity of the essential information these messages contain. The techniques suggested for managing essential processing can be summed up as the modality principle.

1. Modality principle. Learning efficiency is associated with visual and auditory modes. Mayer (2014) argued that a mixed-mode presentation of information (i.e., partly visual and partly auditory) is more effective than a signal-mode presentation (i.e., purely visual or purely auditory) of the same information.

Generative processing is a type of cognitive processing that endeavors to make sense of learning materials and is governed by individuals' learning motivation. It is similar to the germane cognitive load in cognitive load theory. In terms of instructional design technique, it is associated with the multimedia principle.

1. Multimedia principle. Mayer's (2005) multimedia principle holds that learning via words and pictures is more effective than learning with words alone. Verbal content can be printed, spoken, or audio-recorded. With advances in technology, visual learning content comprises a broad array of forms including illustrations, graphs, charts, photographs, diagrams, animations, videos, and three-dimensional graphics. Studies focusing on the multimedia principle (Mariano, 2014; Marković, Vukovac & Kliček, 2015; Fiorella & Mayer, 2016) have shown that presentations containing both verbal and visual content within a system, program, or learning materials tend to increase learner performance on retention and transfer tests. Mayer (2014) concluded that overall, the multimedia principle has weaker effects on retention than on transfer learning. However, the definition of this principle is relatively loose, and results may vary depending on the proximity and sequencing of the visual and verbal elements. In other words, instructional designers and instructors must consider the aforementioned temporal-contiguity and spatial-contiguity principles when applying multimedia content to their instruction, rather than relying on the multimedia principle in isolation.

2.2 CTML in S/FL Learning

In the specific context of language learning, Plass and Jones (2005) have indicated that multimedia-enhanced materials should be used to guide what students notice about words and images – a finding that clearly echoes the multimedia principle. Similarly, Koehler, Thompson, and Phye (2011) found that a multimedia system with features for accessing verbal and pictorial information affected learners with different knowledge levels differently, with the less-knowledgeable students benefiting the most from it. As noted above, the multimedia principle only provides a general concept of multimedia learning; yet, most studies have confirmed that the combination of text with images helps language learners learn vocabulary. Based on their empirical study of French S/FL learners, Jones and Plass (2002) concluded that individuals remember word translations more accurately when the materials incorporate both written and pictorial support rather than only one or the other. Similarly, Lin and Tseng (2012) showed that beginner-level learners of English as a second language (ESL) learned difficult words more effectively in an online multimedia reading passage with textual definitions videos than they did with either textual definitions and pictures, or textual definitions alone – indicating that dynamic graphics promote learning more than static graphics do. And Kuo et al. (2013) found that students using a multimedia-supported system learned English vocabulary more effectively than those who learned it in a traditional classroom.

Of Mayer's (2014) seven principles, redundancy has been focused on the most in the S/FL literature, and has yielded mixed results. On the one hand, Diao, Chandler, and Sweller (2007) found that beginners seemed to acquire less lexical knowledge when presented with both spoken and written text than when they were presented with written

text alone. The authors suggested that beginners' listening rates might be lower than their reading rates, and thus that simultaneous presentation of the textual and audio forms of the same material could have negative learning effects for them. Moussa-Inaty, Ayres, and Sweller (2012) obtained similar results: that when advanced English-as-a-foreign-language (EFL) learners learned the same materials from the reading-only group and reading-and-listening group, they performed better on a listening test in a reading-only condition than in a reading-and-listening condition. The two aforementioned studies imply that redundancy effects may hinder language learning.

On the other hand, some studies have indicated that redundant messages may help S/FL learning. Samur (2011) found that beginner-level learners of Turkish who received animation with concurrent narration and text presentation remembered more vocabulary than those who received animation with concurrent narration but no text – a result that is inconsistent with the redundancy principle. Samur suggested that when text has the function of translation, it can help beginner-level language learners to connect words to their meanings, and thus to remember more vocabulary. Mayer, Lee, and Peebles (2012) provided further support for the idea that redundant information may promote language learning. Working with a sample of college students who were learning academic content in their second language, the authors added redundant videos to an instructional audio podcast, and redundant captions to a video lecture. They found that adding redundant video elements to audio materials helped their participants to learn new knowledge in their second language, though adding on-screen subtitles to animated video did not promote learning. Mayer et al. proposed that their inconsistent results might be attributable to the peculiarities of learning *in* a second language rather than S/FL learning *per se*. However, the present author would argue that Mayer et al.'s participants could be classed as advanced second-language learners, and therefore as potentially using learning strategies similar to those of native speakers. However, more empirical studies are required.

Chinese-as-a-second/foreign-language (CS/FL) studies have also applied the signal principle to listening and grammar learning. Signal effects are added to focus learners' attention and can be incorporated into text, images, or both. An experimental study by Jone and Plass (2002) used both text and pictorial forms, and found that the comprehension of French learners with low prior knowledge of the language was improved when their listening materials provided pictorial and written annotation. Koehler et al. (2011) found that ESL students with low prior knowledge of English performed better on a passive-voice grammar test after using a multimedia instructional program, and ranked its highlighting and clickable annotations as highly helpful features. In short, signal effects appear to promote learning among beginner-level language learners.

Regarding the spatial-contiguity principle, Lee and Kalyuga (2011) investigated the effect of the layout of pinyin and Chinese characters on beginner-level Chinese learners' vocabulary learning. Crucially, they found that a vertical layout with characters on top/bottom andpinyin at the top/bottom could reduce split-attention effects, thus enhancing two-character (i.e.wèizhì (位置)) Chinese vocabulary learning.

The coherence principle has seldom been applied to research on S/FL learning. Gemino's (2005)study of a technology-mediated cooperative online system concluded that chat rooms with context-relevant graphics can have significantly positive effects on learners' knowledge application. However, this finding was not derived from language learners, and more empirical work will be needed to establish whether such technology's deployment in S/FL settings would yield similar positive effects.

In sum, the existing body of CTML-based research on S/FL learning is limited to vocabulary learning, and its findings mainly support just three of CTML's seven principles (i.e., the multimedia, signal, and spatial-contiguity principles). The redundancy principle has been applied in several studies, but their conclusions have been inconsistent, while the coherence, temporal-contiguity, and modality principles have been largely ignored by language-education researchers.

In part because of the S/FL literature's above-mentioned patchy coverage of CTML's key principles, many teachers may not be aware of these principles when designing their teaching materials (Kalyuga, Chandler, & Sweller, 1999). As such, it is essential to heighten pre-service teachers' awareness of CTML, especially in the context of designing multimedia learning materials.

3. Methods

The study used quantitative methods to analyze online lessons' slideshow presentations, animations and video clips created by 15 pre-service teachers in Taiwan. Only half of the participants used dynamic graphics, so CTML's modality, redundancy, and temporal-contiguity principle will not be discussed due to validity concerns.

3.1 Research Context

This study collected the instructional materials designed by 15 graduate student teachers (aged 23-28 years) in 2014 and 2015 as part of an online practicum course in a CS/FL teacher-training program in Taiwan. Through partnership with a private university in the United States, this course – titled Studies in Distance Learning for Chinese – incorporated four hours of online field practice in 2014, and five hours of such practice in 2015. The course's main instructional objectives were to develop pre-service teachers' knowledge of technology integration though five training strategies, *practicum*, *course design*, *advisors*, *peer cooperation*, and *reflections* (Cheng, 2016). Accordingly, the course content included technological resources associated with online education (e.g., online platforms, online resources) and pedagogical strategies associated with online language instruction (questioning, online activities, i+1, and spiral design) as well as the content that the pre-service teachers were expected to teach. Peers and course instructors reviewed the participants' materials before each online session. CTML was not specifically introduced in this course.

During the online lessons, as their outside class activities, American college students were allowed to practice their Chinese oral and listening skills and to learn new

vocabulary. The American students all had an intermediate level of Chinese knowledge, and were enrolled in a face-to-face Chinese class using Integrated Chinese Level 2 Part 1 as their textbook. Learning themes drawn from the American class included *introductions*, *campus life*, *hobbies and pastime*, *part-time job*, and *school system*. New vocabulary was provided by the Taiwanese online student teachers when it was pertinent to cross-cultural topics or otherwise meaningful for communication. To promote the American students' oral outputs, the pre-service teachers' questioning sometimes included specific vocabulary and grammatical structures that the former had already learned.

3.2 Participants

All of the pre-service teachers who enrolled in Studies in Distance Learning for Chinese in 2014 (n=11) and 2015 (n=4) were approached to participate in this study, and all agreed to do so. All the participants were female. Two of them did not provide any information about their teaching experiences (YUZ and LI). Prior to enrolling in this graduate course, seven of them (ME, MI, PI, YIN, MeN, XU, and HU) had some overseas Chinese-as-a-foreign-language (CFL) teaching experience. One (YA) did not have any experience of teaching Chinese, and six had little experience of it. Three of them had online tutoring experiences (QI, YIW, and MeN). None had taught CSL for more than two years.

Table 2: Participants' Backgrounds

ID	Year	Gender	CSL teaching experience
ME*	2014	F	One month: summer camp teacher in Taiwan Two weeks: Chinese teacher in Thailand Five months: Chinese intern teacher at a language center in Taiwan
MI*	2014	F	One year: Chinese instructor at a language center in Taiwan One year: Chinese instructor in Malawi
PE	2014	F	Three weeks: Chinese intern teacher at Beijing International School
PI*	2014	F	Two weeks: Chinese teacher in Thailand Two weeks: Chinese summer camp instructor in Taiwan
QI	2014	F	10 hours: online Chinese tutor
YA	2014	F	None
YIN*	2014	F	One month: summer camp language teacher One year: Chinese instructor at a language center in Taiwan Six months: Chinese instructor at Oak Hill School in the United States
YIS	2014	F	Nine hours: Chinese summer camp cultural instructor in Taiwan
YIW	2014	F	36 hours: Chinese instructor for young adults in Taiwan Three weeks: Chinese intern teacher at Beijing International School 10 hours: online Chinese tutor
YU	2014	F	Three weeks: Chinese intern teacher at Beijing International school One month: Chinese summer camp instructor in Taiwan
YUZ	2014	F	No information provided
LI	2015	F	No information provided
MeN*	2015	F	Two months: Chinese summer camp cultural instructor in Taiwan

			One month: online tutor, Princess Sumaya University for Technology, Jordan
			One month: intern teacher, Pretoria Chinese School, South Africa
			One year: TA, Huish Episcopi Academy, England
			One month: TA, The Howard County Public School, USA
XU*	2015	F	One year: Chinese teacher in Taiwan
			One year: Chinese teacher in Japan
HU*	2015	F	Two weeks: Chinese intern teacher at Beijing International School
			One year: Chinese TA in a high school in Korea

* Indicates a pre-service teacher with overseas Chinese-teaching experience.

3.3 Procedures

Data were collected according to the following procedures. First, at the beginning of each semester, the researcher distributed an online questionnaire regarding the participants' demographic information and professional experience. Consent forms were also collected. As shown in Table 3, each participant in 2014 taught five hours of online lessons, and each participant in 2015, four hours. All of this instructional material, a total of 71 hours, was collected, and one hour of material designed by each of the 15 participants was selected randomly for analysis. The final sample of material included four hours from session 1 (ME, YA, YUZ, and HU), three hours from session 2 (MI, YIN, and LI), three hours from session 3 (PE, YIS, and MeN), three hours from session 4 (PI, YIW, XU), and two hours from session 5 (QI and YU). Slideshows, videos, audio, and screen-capture videos of their online lessons comprised the majority of the data analyzed in this study.

Table 3: Data Collection

ID	Year	Practicum hours	Selected materials
ME*	2014	5	Session 1
MI*	2014	5	Session 2
PE	2014	5	Session 3
PI*	2014	5	Session 4
QI	2014	5	Session 5
YA	2014	5	Session 1
YIN*	2014	5	Session 2
YIS	2014	5	Session 3
YIW	2014	5	Session 4
YU	2014	5	Session 5
YUZ	2014	5	Session 1
LI	2015	4	Session 2
MeN	2015	4	Session 3
XU	2015	4	Session 4
HU	2015	4	Session 1
Total		71	

3.4 Data Analysis

Although 71 hours of materials were obtained, technical issues caused some of the participants' video clips to go missing, while some pre-service teachers shared one student, so those teachers had fewer practicum hours. It was for these reasons that the researcher decided to randomly code one session from each teacher, with the aim of

observing an equal amount of data from all the participants. As a result, 15 hours of material were used for further analysis, and identified according to both the participant who created it, coded in letters, and the number of the session it was created for, coded as a numeral: i.e. ME1, MI2, PE3, PI4, QI5, YA1, YIN2, YIS3, YIW1, YU2, YUZ4, LI2, MeN3, XU4, and HU1 (Table 5).

Then, the researcher calculated the number of dynamic graphics and presentation slides that incorporated both static graphics and text, to establish the pre-service teachers' usage of multimedia. Next, to test the operation of the signal principle, the researcher calculated the number of the presentation slides that used signal cues; for the coherence principle, the number of presentation slides containing seductive details; and for the spatial principle, the number of slides containing layouts of (1) Chinese characters, vocabulary, and sentences and pinyin and (2) graphics and text. Finally, the participants' levels of consistency for each design principle were calculated as percentages.

4. Results

The current study first observed the verbal and pictorial messages placed in their instructional materials by pre-service teachers, and then analyzed these designs in light of CTML.

4.1 Research Question 1: Forms of Multimedia that Pre-service Teachers Use

The pre-service CSL teachers recruited for this study tended to use both words and graphics in their slideshow presentations. On average, as shown in Table 4, approximately 77% of the online materials they created contained both graphics and words. Nine of the participants' materials used this combination in 80% of their total number of presentation slides, while only four used it in 60% of their slides or less.

Table 4: Pre-service Teachers' Lessons That Used Both Words and Pictures

ID	MI2	YIS3	PE3	QI5	PI4	YIW1	YU2	HU1	MeN3	LI2	ME1	XU4	YIN2	YA1	YUZ4	average
%	100%	94%	92%	91%	90%	86%	86%	83%	80%	73%	62%	60%	59%	51%	45%	77%

Nine participants also included animations and/or video clips in their online lessons, and all such material was analyzed. Among these nine teachers, three (EM, YA, and LI) used existing YouTube videos, two (MI and YIN) used self-created videos, and four (PE, PI, YIS, and MeN) used online animations created by themselves through an online animation app that had been introduced to them as part of their curriculum (Table 5). The self-created videos were mostly used for introducing campus life, while animations were employed for listening exercises, and YouTube videos for both of the above purposes plus the presentation of Chinese songs.

Table 5: Pre-service Teachers' Dynamic Graphics Usage

ID	animations	videos	Notes
ME1*	0	1	YouTube videos for songs
MI2*	0	2	Self-created videos for campus life, and YouTube videos for listening practice

PE3*	1	0	Animations for listening practice
PI4*	1	0	Animations for listening practice
QI5	0	0	
YA1*	0	1	YouTube videos for songs
YIN2*	0	1	Self-created videos for campus life
YIS3	1	0	Animations for listening practice
YIW1	0	0	
YU2	0	0	
YUZ4	0	0	
LI2*	0	1	YouTube videos for campus life
MeN3*	1	0	Animations for listening practice
XU4	0	0	
HU1	0	0	
Total	4	6	

* Indicates a participant who used dynamic graphics.

Given that more than half of the participants applied dynamic graphics and three-quarters a combination of static graphics with text, it would appear that – consciously or unconsciously – most of these pre-service teachers were aware of the multimedia principle. This is perhaps not unexpected, as all were in their 20s and had extensive experience of using technology in their personal lives. However, as Mayer (2014) has indicated, simply using combinations of pictures and text in the design of instructional material does not guarantee learning effectiveness, and proper use of multimedia requires that one understands both the theoretical and the practical underpinnings of one's lessons. Accordingly, the current study further investigated the participants' online lesson designs based on the signal, coherence, and spatial-contiguity principles, to assess their levels of professional knowledge of multimedia principles and whether they applied such knowledge consistently.

4.2 Research Questions 2 and 3: The Participants' Levels and Consistency of Professional Knowledge of Multimedia Learning Principles

4.2.1 The Signal Principle

Because the foci of the participants' course and the classes they taught were spoken-Chinese skills and cultural- or theme-based vocabulary learning, this study did not focus on the use of text or graphics in reading or writing exercises. Thus, the investigation of signal messages in the participants' online lessons focused on their presentations aimed at vocabulary learning. Data analysis revealed that the pre-service teachers' signal cues were of three general types: text-based, symbol-based, and both. Only two participants (ME and MI), both from the 2014 group, did not use any signal effects in their online lessons.

As shown in Table 6, the pre-service teachers in this study used three strategies for their text-based designs: font coloring, frame coloring, and both. Figure 1 presents examples from the preservice teachers' online lessons. Frame coloring was the most favored strategy when presenting new vocabulary (n=11, 73%), while the font-and-frame strategy was the least used (n=2, 13%). Font coloring was used by nearly half the participants (47%).
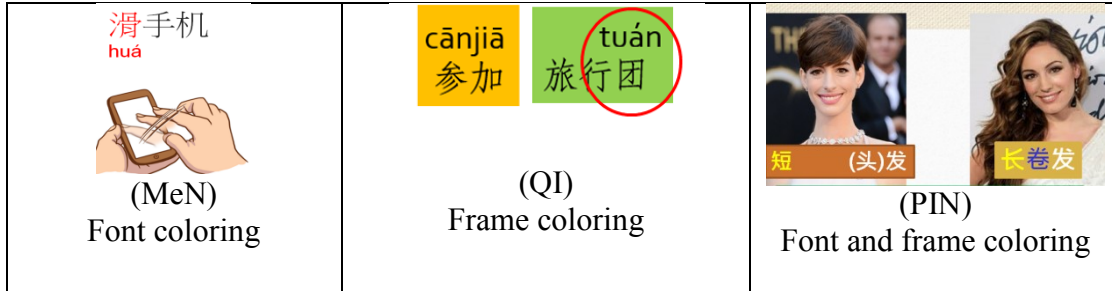
Figure 1: The Participants' Three Strategies for Text-based and Symbol-based Design

The symbol-based strategy can be further categorized into approaches that use true symbols and those that use shapes (Figure 2). As Table 6 indicates, slightly more than half of the participants (n=8) preferred true symbol and shape strategies (n=8, 53%). Overall, 87% of the pre-service teachers (n=13) applied signal strategies to enhance vocabulary learning.
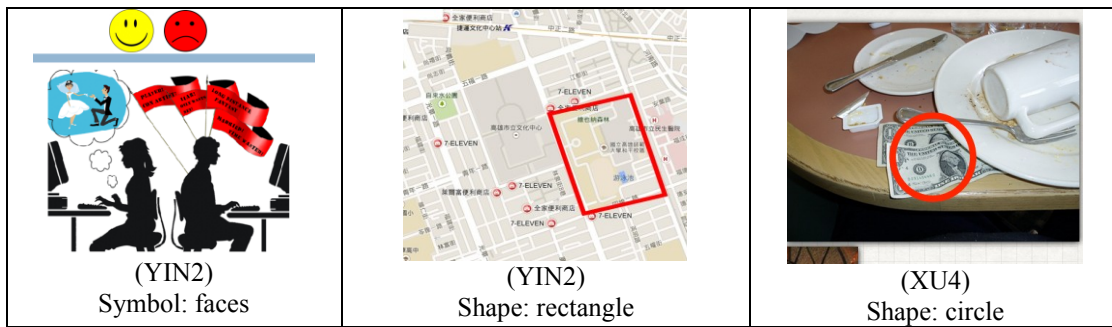

Figure 2: The Participants' Strategies for Symbol-based Design

Table 6: Signal Principle Presentation Types

Types	Designs	Total number	%	ID
text-based	font coloring	7	47	PE3, PI4, YA1, YIN2, YUE2, LI2, MeN3
	frame coloring	11	73	PI4, QI5, YIN2, YIS3, YIW1, YUE2, YUZ4, LI2, MeN3, XU4, HU1
	font and frame coloring	2	13	PIN4, YIN2
symbol-based	symbol	8	53	PE3, PI4, YIN2, YIW1, YUE2, LI2, MeN3, HU1
	shape	8	53	PE3, PI4, QI5, YIN2, YIS3, YUE2, LI2, XU4

In terms of consistency, most of the pre-service teachers used some cues in their materials, but they did not present their signals consistently. As Table 7 shows, only one online lesson (by MeN) that applied signal effects for vocabulary learning could be characterized as having consistent designs, while 12 (80%) were incosistent, and the other two did not use any signal cues. This finding suggests that, while most of these pre-service teachers did not possess knowledge of the signal principle, they nevertheless used cues of some kind to present new vocabulary. However, due to their lack of theoretical grounding, those cues were essentially meaningless. As this technique is strongly associated with Chinese vocabulary learning, teacher educators should introduce the signal principle to the pre-service teachers to help them stabilize their designs.

Table 7: Pre-service Teachers' Use of the Signal Principle

ID	Number of consistent designs	Number of vocabulary-learning slides using the signal principle	% of consistent designs
MeN3	5	5	100%
QI5	4	6	67%
PE3	6	11	55%
YUE2	6	11	55%
YIS3	4	8	50%
XU4	3	7	43%
YIN2	3	8	38%
PIN4	3	9	33%
YUZ4	1	3	33%
HU1	2	9	22%
YIW1	1	5	20%
YA1	0	1	0%
LI2	0	9	0%
Average			40%

4.2.2 The Coherence Principle

As previously discussed, the coherence principle revolves around the presence and absence of seductive details in learning content. For purposes of the current study, the term seductive details refers to graphics and words unrelated to the learning theme: e.g., the princess and associated text in the left-hand panel of Figure 3, which are unrelated to the theme "making online friends", and the cupcake in the right-hand panel of the same figure, which is unrelated to the learning theme "boy/girl friend". Rather than promoting learning, such seductive details and may even hinder it by distracting learners' attention. Further investigation of the consistency of the pre-service teachers' lessons vis-a-vis the coherence principle was necessary to determine whether they possessed knowledge of that principle.

Figure 3: Examples of Seductive Details (Coherence Principle)

Table 8 shows that the number of multimedia slides produced by individual participants ranged from a low of seven to a high of 49. Two pre-service teachers (YA and LI), who did not use any animation effects in their designs, used the most slides: 48 and 49, respectively. Those who took advantage of the animation and placed many graphics and words in each slide (e.g., YIW) created much smaller numbers of slides.

Regarding seductive details in those slides, on average, 16% of the sampled online lessons contained seductive details, and only three of the participants' materials (PI, YUZ, and XU) did not contain any seductive details. At one extreme, the materials created by PE and YIS contained 54% and 33% irrelevant graphics and text, respectively. Two-thirds of the participants' lessons contained between 9% and 27% seductive details. These findings imply that 80% of these preservice teachers (n=12) were unaware of the negative learning impact of irrelevant graphics and text, i.e., that they lacked knowledge of the coherence principle.

Table 8: Pre-service Teachers' Use of the Coherence Principle

ID	seductive details	total number of multimedia presentation slides	%
PE3	7	13	54%
YIS3	6	18	33%
MI2	4	15	27%
ME1	6	29	21%
LI2	9	48*	19%
QI5	2	11	18%
YA1	7	49*	14%
YIW1	1	7**	14%
YIN2	3	22	14%
YU2	3	22	14%
MeN3	2	20	10%
HU1	2	23	9%
PI4	0	10	0%
YUZ4	0	11	0%
XU4	0	20	0%
Average			16%

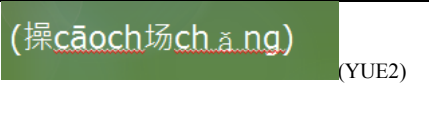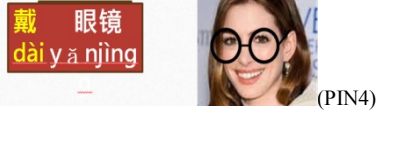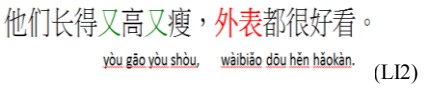* Indicates a participant who used high number of slides

** Indicates a participant who used lowest number of slides

4.2.3 The Spatial Principle

Based on Lee and Kalyuga's (2011) previously cited findings on the effects of layout, and on Mayer's (2014) definition, the spatial contiguity of the participants' designs can be categorized into two types: text only, and graphics and text. The first refers to the vertical or horizontal presentation of pinyin and Chinese characters, vocabulary, or sentences, as shown in Table 9. The latter refers to related graphics and texts that are presented in close proximity.

Table 9: Examples of Spatial Contiguity

Text	Examples	Descriptions
Characters	(HU1)	Vertical presentation of Chinese **characters** and pinyin

Vocabulary	(操cāoch场chǎng) (YUE2)	Horizontal presentation of Chinese **characters** and pinyin
	戴 眼镜 dài yǎnjìng (PIN4)	Vertical presentation of Chinese two-word **vocabulary** and pinyin
	內向 nèixiàng (YIS3)	Horizontal presentation of Chinese two-word **vocabulary** and pinyin
Sentences	他们长得又高又瘦，外表都很好看。 yòu gāo yòu shòu, wàibiǎo dōu hěn hǎokàn. (LI2)	Vertical presentation of Chinese **sentences** and pinyin

As shown in Tables 9 and 10, the participants applied five types of text-only layouts. Each pre-service teacher applied at least one type of spatial-contiguity strategy to her lesson. Nearly all (93%, N=14) of the participants presented Chinese vocabulary and pinyin vertically when teaching vocabulary, and 40% (N=6) presented Chinese vocabulary and pinyin horizontally. Few participants (N=5) applied a spatial-contiguity strategy to the presentation of Chinese characters (N=3) and sentences (N=2), possibly because the instructional objectives focused on listening and speaking. As a general matter, when the text versions of teachers' questions are presented simultaneously to the teachers' spoken output, it is difficult to determine whether learners' comprehension of the questions is attributable to their listening or reading skills; and this assessment-related difficulty could explain why relatively few examples of presenting Chinese sentences and pinyin were observed in this study.

As indicated in Table 10, all of the pre-service teachers' lessons contained examples of words presented near the corresponding graphics.

Table 10: Spatial-Contiguity Principle Presentation Types

types	designs	number of teachers	%	ID
text only	Vertically presentation, Chinese **characters** and pinyin	1	7%	HU1
	Horizontal presentation, Chinese **characters** and pinyin	2	13%	PE3, YUE2
	Vertical presentation, Chinese two-word **vocabulary** and pinyin	14	93%	ME1, PE3*, PIN4, QI5, YA1, YIN2, YIS3, YIW1, YUE2*, YUZ4, LI2, MeN3, XU4, HU1
	Horizontal presentation, Chinese two-word **vocabulary** and pinyin	6	40%	MI2, PE3*, YIN2*, YIS3*, YUE2*, HU1*
	Vertically presentation, Chinese **sentences** and pinyin	2	13%	YIN2, LI2
graphics and text	Words and graphics presented in close proximity	15	100%	ME1, MIN2, PE3, PIN4, QI5, YA1, YIN2, YIS3, YIW1, YUE2, YUZ4, LI2, MeN3, XU4, HU1

* Indicates a participant who used both horizontal and vertical design.

Table 10 also reveals that five participants (PE, YIN2, YIS3, YUE2, HU1) presented Chinese two-word vocabulary and pinyin inconsistently, i.e., both horizontally and vertically. As shown in Table 11, however, approximately 89% of the pre-service teachers' lessons consistently presented graphics and related text in close proximity to each other. All the lessons created by six of the pre-service teachers (PIN, QI, YUZ, LI, MeN, XU) followed the spatial-contiguity principle. One participant (PE) did not show any consistency, while four others (YIN, YIS, YUE, HU) did not present coherent layouts for their Chinese vocabulary and pinyin, and also produced weak designs in terms of text/graphics proximity. Overall, regarding the spatial-contiguity principle, five of the 15 preservice teachers (33%) appeared to lack knowledge of the spatial-contiguity principle for integrating multimedia into their instruction.

Table 11: Presentation of the Spatial-Contiguity Principle

ID	Text and corresponding graphics presented in close proximity	Total number of slides including graphics and corresponding text	%
PIN4	9	9	100%
QI5	7	7	100%
YUZ4	3	3	100%
LI2	25	25	100%
MeN3	13	13	100%
XU4	5	5	100%
YA1	18	19	95%
MI2	11	12	92%
ME1	15	17	88%
HU1	12	14	86%
YIS3	13	16	81%
YUE2	13	16	81%
YIW1	4	5	80%
YIN2	10	14	71%
PE3	7	12	58%
Average			89%

To sum up, the pre-service teachers in this study used both static and dynamic graphics and words, and approximately 60% of them applied dynamic graphics for online spoken-Chinese lessons. Dynamic graphics including YouTube videos, self-created videos, and animations were all applied to serve clear instructional purposes.

As a group, the participants possessed considerable knowledge of multimedia principles, but exhibited wide variation in their understanding of the concepts of the signal, coherence, and spatial-contiguity principles. For example, approximately 87% (n=13) understood the signal principle, but 80% (n=12) did not produce consistent designs.

Moreover, the materials produced by just 20% (n=3) of these pre-service teachers reflected the coherence principle, while among the lessons created by the remainder of the sample (80%, n=12), 16% contained seductive details. In other words, despite 80% of the participants not possessing knowledge of the prinicple, seductive-message effects remained relatively rare in their work.

All 15 participants applied at least one type of spatial-contiguity strategy to their lessons, though 33% (N=5) did not do so consistently.

5. Conclusion

The participants in this study, all of whom were under age 30, mostly applied combinations of graphics and and text to their instructional designs. These results reflect that most young pre-service CSL teachers possess technology-related knowledge, and are adept at finding graphics, typing Chinese characters, editing videos, and searching for online videos suitable to Chinese online instruction. Such knowledge should be treated as fundamental for online teachers, as also recommended by Cheng (2016), who found that teachingonline lessons drew heavily upon pre-service teachers' knowledge of technology integration. However, the fact that it is not especially difficult for young teachers to apply multimedia to their instruction can mask that they may or may not be doing so in accordance either with multimedia theory or with how people learn in real-world situations.

The findings of this study have important implications for CS/FL teacher training. Variations in individuals' instructional instincts mean that some CTML principles are applied consistently and others are not. Thus, Chinese teacher-educators should discuss Mayer's (2014) multimedia principles in detail, and and actively redress gaps in their students' knowledge of these principles to reinforce their professional skills.

The main findings of this study are as follows. First, most of the pre-service teachers applied some type of signal message in their lessons, but the majority who did so were inconsistent in how these signals were presented, and thus appear to have lacked deep knowledge of the signal principle. The purpose of such signals is to catch learners' attention, and only a consistent presentation can serve this purpose effectively over time, since cues as color, framing, and font style become meaningful to learning. Making learning meaningful is also the primary goal of CTML (Mayer, 2014).

Second, although seductive details were observed in less than one-fifth of lessons from twelve pre-service teachers, many of the participants were found to be unaware of the coherence principle. Pre-service teachers should not only be aware of their use of graphics as content, but also the overall graphic design of their presentations. In presentation slides, simple outlining and solid colors are recommended for background designs in preference to photos and complex graphics. Lastly, it seems that all of the pre-service teachers understood the spatial-contiguity principle, but 33% of them nevertheless applied it inconsistently.

In terms of instructional implications, this study's findings regarding the signal principle could be applied to Chinese vocabulary teaching through consistent use of colors or framing to differentiate the functions of vocabulary: e.g., red for verbs and black for nouns. Likewise, in keeping with the present study's findings and those of Lee and Kalyuga (2011), the spatial-contiguity principle can be upheld via the consistent vertical presentation of two-word vocabulary and pinyin, which minimizes the split-

attention effect and thus may help learners to quickly identify the correct pronunciations of characters. The present study's results also confirmed that pre-service teachers are likely to design online course materials with irrelevant graphics or text; because such elements may distract students' attention, teacher-educators should devote more time to helping their students avoid it. Perhaps most importantly, in the case of speaking-and-listening lessons, it is critical that graphics and text work together and in keeping with CTML's signal, spatial, and coherence principles. It is therefore recommended that teacher-training courses on multimedia integration should make CTML central to their efforts to promote pre-service teachers' professional and skills.

This study has some limitations. First, data on the content of dynamic graphics were not analyzed because of the smallness of the sample, and this meant that a full examination of the respondents' work in CTML terms – i.e., including the modality, redundancy, and temporal-contiguity principles – was not possible. Second, the study's findings are associated with online lessons designed in Asia for speaking and listening practice in an Asian language; thus, its conclusions might not be generalizable to online lessons in reading and writing; to face-to-face educational settings; or to other cultural/lingusitic settings. Accordingly, future research should gather data on dynamic graphics and use it to investigate the modality, redundancy, and temporal-contiguity principles, as well as data from lessons with different learning themes or instructional objectives such as reading or writing, and data from additional countries. Finally, a larger and more diverse future sample should also include in-service teachers.

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