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An Empirical Study of Optimizing Cognitive Load in Multimedia Integrated English Teaching

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Abstract
Cognitive load is one of the important factors influencing complex learning. The article introduces relevant research in optimizing cognitive load in multimedia learning from abroad and in China. Results of the empirical study of the instructional design in the multimedia Integrated English show that the means of all the scores in the tests and the number of the students who pass the TEM-4 in the experimental group are higher than those in the control group, among which significant differences can be found in Cloze, Vocabulary and Structure Reading Comprehension, Paraphrasing and Total Score between the experimental group and the controlled group whereas no significant differences exist in their average score in Translation and Writing. The study indicates that optimizing cognitive load in the multimedia learning facilitates improving English learning efficiency.

Key words: Multimedia English learning; Extraneous cognitive load; Intrinsic cognitive load; Germane cognitive load; Optimization

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INTRODUCTION
In cognitive psychology, cognitive load is the load related to the executive control of working memory (WM). Thereafter, the major goal of learning lies in the acquisition and automation of schematic knowledge structures in long-term memory. The cognitive processing of multimedia information involves selection, organization and integration, during which all elements like the amount of information and interactions must be processed before the meaningful learning can continue. However, with the wide use of the multimedia English teaching, complex learning tasks, diversified language input, intricate PPT presentations challenge a learner's working memory, unavoidably lead to students' cognitive overload and constrain teaching effects. Consequently, how to optimize cognitive load in the multimedia English teaching is of vital importance in improving English learning efficiency.

Based on the empirical study of optimizing cognitive load in the multimedia Integrated English teaching of the 60 English majors in a university in China, the article aims at exploring how information presentation facilitates learners' activities to optimize their intellectual performance, probing how the instructional designers control the conditions within the multimedia learning environment and the instructional effects so as to provide an insight into improving the instructional design in the multimedia Integrated English teaching.

1. RESEARCH BACKGROUND
Aiming at predicting learning outcomes by considering the capabilities and limitations of the human cognitive architecture, Cognitive Load Theory (CLT), put forward by Sweller in 1988, maintains that cognitive load should be controlled so that meaningful learning can occur in the interactions of all elements. As working memory

is limited in capacity (Miller, 1956) and duration (L. Peterson & Peterson, 1959), all instructional material imposes a working memory or cognitive load, and that cognitive load can be divided into extraneous cognitive load, intrinsic cognitive load, and germane cognitive load.

> Intrinsic , extraneous, and germane cognitive load are addictive in that , together, the total load cannot exceed the working memory resources available if learning is to occur. The relations between the three forms of intrinsic load, extraneous load, and germane load are asymmetric. Intrinsic cognitive load provides a base load that is irreplaceable other than by constructing additional schema and automating previously acquired schema. (Paas et al., 2003)

To help learners maximize their working memory resources, Clark (2003). Lee et al. (2006) holds employing graphs, Kester et al. (2006) proposes constructing just-in-time model to present information. Mayer & Moreno (2002) suggests adopting multi-presentation effect , congruity effect , coherence effect and redundancy effect in the multimedia instructional design. Clark (2006) thinks that multipresentation effect, dual-code effect, split-attention effect, modality effect, redundancy effect, animations and element interactivity may reduce extraneous load.

As for reducing intrinsic load, Gerjets et al. (2004) follows partial-whole order, Van Merrienboer (2002) presents teaching information by simplifying modules of tasks and steps, Lee et al. (2006), Moreno (2007) displays complex information by segmentation, Renkl (2004) uses fading solutions steps to present incomplete examples. Lee et al. (2006) holds that when the complexity of knowledge lowers, lowering extraneous load and increasing germane load merely works for learners with lower prior knowledge. The more complex the knowledge, the richer prior knowledge the learner has contributed to form a new schema and lowering the intrinsic load.

In terms of increasing germane load, Paas (1994), Sweller et al. (1998) provides working examples, Moreno and Mayer (2000, 2004) promotes individual learning, Seufert and Brinken (2006), Moreno and Mayer (2007) conducts guidance teaching, Moreno and Mayer (2005) ,Hattie& Timperley (2007) organizes feedback teaching, Moreno and Mayer (2007), Moreno and Valdez (2005) undertakes reflection teaching. All these efforts have gained remarkable achievements.

Foreign studies mainly focus on how to control cognitive load in the multimedia teaching while few touch upon foreign language teaching. In China, relevant research mainly concentrates on introducing and application of the CLD (Lu, 2003; Liu, 2006); The article aims at providing insight into optimizing multimedia foreign language learning.

2. AN EMPIRICAL STUDY OF OPTIMIZING COGNITIVE LOAD IN THE MULTIMEDIA INTEGRATED ENGLISH TEACHING

2.1 Purpose

Based on CLT, the study aims at exploring learning effects after optimizing the extraneous cognitive load, reducing the intrinsic cognitive load and increasing germane cognitive load in the instructional designs of the multimedia Integrated English teaching. If the academic performance and the passing rate of TEM-4 (Test for English Majors Band-4) of Group A (the controlled group) is higher than that of Group B (the contrast group), it justifies the practicability of the instructional design.

2.2 Participants

60 participants are sophomores of English majors in a university in China. Each of the controlled group A and the contrast group has 30 students, The average score of their Integrated English is respectively 71.0167 and 71.4667. The Independent *T*-test result shows that when F=.655, P=.422>.05, there is equal variances assumed; when t=-.151, df=58, P=.881>.05, the academic performance of the two groups is homogeneous, carrying no significant differences.

Besides, teachers of the Controlled Group A and the Contrast Group B are lecturers, M.A, respectively.having 4- year and 3.5 year teaching experience. They adopt the same textbook *Contemporary College English* (Book Three & Book Four), teach the same texts, keep almost the same pace of teaching progress. The empirical study lasts for one year.

2.3 Instructional Design

Starting from CLT, Teacher A in the Group A consciously follows instructional design principles to optimize students' cognitive load in her teaching whereas Teacher B emphasizes designing beautiful and intricate PPT, with complete texts, impressive sound effects and abundant information. Her instructional design tends to be of contextualization, dramatization and gamification. Stressing interactions among students and the teacher, both teachers endeavor to make their class interesting and lively by interweaving background music, jokes, English songs, brain twister and organizing presentations, debate, discussion and role-play.

2.4 Research Instruments

As the final exam of Integrated English does not involve listening and oral English, the study employs written examination as a major research instrument which contains Reading Comprehension, Vocabulary &

Structure, Cloze, Paraphrasing, Translation and Writing with a full score of 100, and participants' scores of Integrated English in the first grade as a reference to check their English proficiency. To reduce the potential influence from the teachers ,both Teacher A and Teacher B failed to attend designing the final examination. The statistical analysis of the results is conducted with the software of SPSS 13.0.

3. FINDINGS AND DISCUSSION

3.1 Data Analysis

Table 1 shows that in the first semester of the second-year, the average score of Group A in Cloze, Vocabulary & Structure, Reading Comprehension, Paraphrasing, and their Total is respectively 1.0166, 1.5, 2.5333, 1.6166 and 8.15 points higher than that of Group B, carrying significant difference (p <.05). However, though Group A's average score in Translation and Writing is respectively 0.3 and 0.1833 points higher than Group B's, it carries no significant difference (p >.05).

Table 2 shows that in the second semester of the second year, Group A's average score in Cloze, Vocabulary & Structure, Reading Comprehension, Paraphrasing and the Total respectively outdoes Group B's by 0.95, 0.9667, 3.4, 2.6666 and 8.5834 points, carrying significant difference whereas no significant difference can be found in the average score of Translation and Writing between Group A and Group B (p>.05).

Table 1
Paired Samples Test of the Final Examination Scores of Group A and Group B in the First Semester of the Second Year

Group	A			B			Paired-sample *T*-test	
Types of questions	Means	Std. deviation	Std.error mean	Means	Std. deviation	Std.error mean	*t*	Sig.
Cloze	6.63333	1.61850	.29550	5.6167	1.65927	.30294	2.696	.012
Vocabulary &structure	12.0833	2.32706	.42486	10.5833	2.62968	.48011	2.256	.032
Reading Comprehension	14.0000	2.97113	.54245	11.4667	3.67408	.67079	3.357	.002
Paraphrasing	11.0333	2.56278	.46790	9.4167	2.74202	.50062	2.388	.024
Translation	13.1333	2.83735	.51803	12.8333	2.73021	.49847	1.725	.095
Writing	14.6500	2.09741	.38293	14.4667	1.90703	.34818	.459	.650
Total	71.6500	13.96557	2.54975	63.5000	15.21852	2.77851	2.278	.030

Table 2
Paired Samples Test of the Final Examination Scores of Group A and Group B in the Second Semester of the Second Year

Groups	A			B			Paired-sample *T*-test	
Types of questions	Means	Std. deviation	Std.error mean	Means	Std. deviation	Std.error mean	*t*	Sig.
Cloze	6.9833	1.37392	.25084	6.0333	1.43198	.26144	3.110	.004
Vocabulary & Structure	12.8000	1.76459	.32217	11.8333	2.30192	.42027	2.069	.048
Reading Comprehension	13.8000	2.74678	.50149	10.4000	3.87387	.70727	3.985	.000
Paraphrasing	11.2833	3.08970	.56410	8.6167	2.94982	.53856	3.535	.001
Translation	15.2500	2.11216	.38563	14.8333	2.27934	.41615	.754	.457
Writing	14.6500	2.09741	.38293	14.4667	1.90703	.34818	.388	.701
Total	74.7667	11.06465	2.02012	66.1833	13.08690	2.38933	3.092	.004

From the cognitive angle, learning itself is the changes of the learners' mental presentations, indicating their construction or reorganization of new linguistic knowledge, or consolidation of its prior one within the SLA context. In the two tests, Group A's average score in Cloze, Paraphrasing and Total higher than Group B 's shows that Group A's command of the inherent logical relations among words, sentences and paragraphs and their English proficiency outdo Group B's. Group A's average score in Reading Comprehension higher than Group B's indicates that Group A's comprehension and inference of the text is much better than Group B's, which

might well attribute to Teacher A's holistic task-based teaching integrating language form and functions, input and output, and various kinds of communicative models.

Because of the natural forgetting index in the foreign language learning environment, English learners' limited language input fails to reach what is needed in the natural language acquisition, neither can it reach the critical index; consequently, it fails to cause successful foreign language acquisition. Divergent parameters between English and Chinese, being lack of genuine language learning environment and limited learning time might result in Group B's average score in Vocabulary & Structure lower than Group A's despite that Teacher B gives highlight to worked examples teaching and lexical explanations, but excessive worked examples might aggravate the students' working memory burden so that they fail to form an effective mental lexicon and semantic network. According to Cognitive Information Processing Theory, human's noticing resources are limited, content and form are always competitive to gain sufficient attention in processing second language information. Generally speaking, students tend to give priority to content while ignoring its form. Both Teacher A and Teacher B stress translation in their teaching, especially Teacher B values students' recitation of the text, which might result in no significant difference in the two groups' average score in Translation.

Writing reflects comprehensively a learner's intellect and skills, involving his/her choice of diction, layout of the article, his/her observation ability and analytic ability. No significant difference in the average Writing score of Group A and Group B suggests that the improvement of writing calls for students' long practice and their accumulation of knowledge, somewhat impossible to gain an immediate success in the short run. Undoubtedly, confined by the time and span, the study is limited in exploring the impacts of multimedia foreign language learning on students' writing.

In the second semester of the second year, 28 students in Group A and 20 students in Group B passed the TEM-4.

3.2 Discussion

3.2.1 Lowering Extraneous Cognitive Load

Based on the multi-presentation effect, Teacher A integrates instruction with the presentations of pictures, tables and animations, recapitultively displays the text consistent with the auditory narration so as to balance the students' visual and auditory modalities, and improve their processing efficiency. Take the Lesson *'Thinking As a Hobby*" as a good example. Teacher A uses a chart to summarize Features of Three-Grade Thinking so as to reduce their cognitive efforts in the cognitive processing.

Table 3
Features of Three Grade Thinking

Thinking	Characteristics	Examples
Grade-three	Ignorance, hypocrisy, prejudice, self-satisfied, contradictions	Mr. Houghton, nine tens of people
Grade-two	Detecting contradictions; do not stampede easily; lag behind, a withdrawal, destroy but not create	Ruth, the author, (maybe) some acquaintances
Grade-one	To find out what is truth, based on a logical moral system	Far and few between, only in books

Following the Congruity Effect and Coherence Effect, Teacher A puts the text adjacent to or embeds it within the picture, endeavoring to reduce interactive forms such as hyperlink, buttons and choice box. According to the Redundancy Effect, he decreases using pictures, background music and sounds interesting but somewhat irrelevant to the subject. Starting from Signaling Effect, she enhances the input by employing bold prints, italics, capitalization, arrows, underlining. straight line, special color or boxed head to make the language points and key points more conspicuous, adopts Entity Relationship Diagram to connect the related content, highlights the essential processing material by pausing, stressing key words and key sentencesso as to help the students to select and organize information, to establish relations in the cognitive cause-and-effect chain, avoid visual searching and distracting their attention.

Deeming grammar & structure teaching as a basic unit, Teacher B elucidates knowledge with rich examples, ranging from word study to the supplementation of related phrases and collocations, then moving to analyze the sentence structure and discourse structure. Besides, she stresses the importance of having the students recite the text. Her exquisite PPT with abundant information contribute to students' acquiring knowledge and information, reducing extraneous cognitive load in the learning task with weak elementary interactivity and improving the students' learning effects. However, overusing screens and worked-example teaching forces students to repeat "searching-matching" in diversified information sources so that they easily feel visually fatigue and attention distraction. Beautiful as l illustrations, animations and background music are to weaken the learning pressure, they are too irrelevant to the teaching task to fully stimulate students' cognitive

potential, impede their learning and increase their extraneous cognitive load.

3.2.2 Reducing Intrinsic Cognitive Load

Teacher A follows Segmentation Principle, Pre-training Principle and Modalities Effect to reduce the students' intrinsic cognitive load. When elements are closely related to each other, Teacher A segments the information to make it more logically coherent with the proper interval to guarantee that the students have enough time to process the essential information by visual and auditory channels. For example, when differentiating synonyms "consider, ponder, meditate, deliberate and contemplate" in the sentence "The muscular gentleman contemplated the hinder-quarters of leopard in endless gloom", Teacher A uses the teaching strategy of induction-explanation-practice or that of induction-exploration-scaffolding to divide the information to be presented into different segments, trying to display a complete text within one screen, leaving the interval sufficient for students to finish their cognitive processing: selection and organization of the fragment of the information.

A mental model construction involves constructing a component model (description about how each component works) and a cause-effect model (description about how a change in a part of the system leads to the change of other parts). Pre-training contributes to students' chunk processing about the learned material based on the knowledge in their working memory, constructing component model and avoid information overload. To help the students grasp the literal meaning and the implication of the phrase "in the endless gloom", Teacher A adopts pre-training to compare the use of Hyperbole in English and Chinese, provides a "pre-organizer" matching with the students' original cognitive architecture to establish a concept framework so that the students can have a good command of the use of Hyperbole in the daily communication. Based on Modalities Effect, Teacher A separates the information presentation modality into two simultaneously. For instance, in demonstrating a picture with its script, Teacher A narrates the script so that the students can choose to process cognitively the key parts in the picture.

Teacher B divides the text learning into different tasks, focusing on training the students' listening, speaking, reading, writing and translation ability by demonstration or practice. When components of each learning task and those between the learning task and the learning objectives are small in number and loosely correlated, such method may lower the students' intrinsic cognitive load and facilitate the meaningful learning. But conversely, the fine subdivision of the learning objectives might do harm to students' overall command of the learning task, constructing a complete schema and impeding their comprehension, judgment and inference.

3.2.3 Increasing Germane Cognitive Load

Both Teacher A and Teacher B advocate students' cooperative learning and the interaction among students and between the teacher and the students to summarize the author's choice of diction, the theme of the text, its discourse structure and writing style for such activities are beneficial to students' storing knowledge in their long memory, getting inspiration and enlightenment and deepening their thinking. At the initial stage, fewer elements of the learning task and lower intrinsic cognitive load are beneficial to students' constructing a partial schema; at the subsequent stage, with the increasing complexity of the learning task, based on the partial schema acquired, students' working memory integrates and assimilates the whole task to from a complete schema and realizes the schema automation.

On the one hand, both teachers undertake "Free Goal Management" in their teaching, encouraging students to self-monitor their learning process so as to coordinate the comprehensive training of their listening, speaking, reading ,writing and translation abilities. The employment of holistic teaching strategies like coaching, scaffolding and model-construction bridges the gap between the worked examples and students' mental model, and balances the breadth and depth of knowledge, the novelty and maintainability of the content, which are conductive to students' constructing intricate schema, differentiating similar features, relevant features from irrelevant ones., improving their analytic, understanding and judging abilities, and inducing the complicated relationship among different elements.

On the other hand, the timely feedback from the teacher and the peers help the students beware the limitations of their inter-language in language rules and language use; besides, the divergences between their inter-language expressions and those of their peers or their teachers might well stimulate their strong learning motivations. All these contribute to increasing germane cognitive load in the multimedia learning.

On the basis of Multi-presentation Effect, Teacher A provides language input and task framework in the holistic-partial-holistic order in the form of chunking, presents the worked examples such as lexical chunking, idiomatic chunking, syntactic hierarchy and discourse hierarchy and specific instructions about finishing the task in a fading-step, paying attention to variations in the worked examples themselves, providing the students some key information such as a part of the answers, a full answer to the key words, and a topic sentence about the explicit processing task to guide the students to understand the text better.

For the same teaching task, background music can improve the students' learning that has richer prior knowledge whereas for those students with poorer prior

knowledge it will produce higher intrinsic cognitive load and germane cognitive load, leading to cognitive overload. Teacher B 's instructional design focusing on contextualization, dramatization and gamification may well stimulate students' mental efforts and learning motivations, but the transfer of students' excitement will undoubtedly weaken the teaching objectives, which will in the long run bring about students' fading learning interest, thwarting learning initiatives and their sustaining mental efforts.

To sum up, Group A's superiority in the average score of each type of the test, the total and the passing rate in TEM-4 to those of Group B is somewhat linked to both teachers' instructional design, the organization and presentation of the teaching material, reflecting that optimizing cognitive load in the multimedia English teaching is effective and stimulative.

CONCLUSION

As a relative concept, "multimedia does not mean the more the better per unit. PPT is just means to enrich and extend multimedia teaching, by no means the replacement of the whole teaching content and instructional modes. Excellent educational technology is anything but the sole guarantee of the teaching quality. Essentially, multimedia English teaching is still language teaching. If the instructional design can consider comprehensively multimedia teaching principles, students' working memory capacity and limitations, their physiological, cognitive and psychological features, coordinate the relationship among teaching content, teaching devices and students' individual differences, control every link in and out of the classroom, lower extraneous cognitive load and intrinsic cognitive load, increase germane cognitive load, it may give the advantages of multimedia teaching into full play, improve students' English proficiency and reach a better learning effects.

REFERENCES

Carroll, W. L. (1999). *Psychology of language* (3rd ed.). Brooks: Cole Publishing Company.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, (8), 29-332.

Clark, R., Nguyen, F., & Sweller, J. (2003). *Efficiency in Learning: Evidence-based guidelines to manage cognitive load*. Pfeiffer Progress: San Francisco.

Cook, C. G. (1990). Cognitive load theory as an aid for instructional design. *Australian Journal of Educational Technology,* (6), 108-113.

Gerets, P., Scheiter, K., & Catrambone, R. (2004). Designing instructional examples to reduce intrinsic cognitive load: Molar versus modular presentation of solution procedures. *Instructional Scien*ce, (32), 33-58.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, (77), 81-112.

Kester, L., Lehnen, C., & van Gerven, P. W. M., et al. (2006). Just-in-time, schematic supportive Information presentation during cognitive skill acquisition. *Computers in Human Behavior*, *22*(l), 93-112.

Lee, H.-J., Plass, J. L., & Homer, B. D. (2006). Optimizing cognitive load for learning from computer-based science simulations. *Journal of Educational Psychology, 98*(4), 902-913.

Liu, L. D. (2006). Cognitive load theory and its application in the foreign language instructional design. *Language Teaching and Research*, (2), 73-80.

Lu, Z. (2003). Cognition and the multimedia foreign language instructional design. *Foreign Education*, (4), 47-50.

Mayer, R. E., & Moreno, R. (2002). Aids to computer-based multimedia learning. *Learning and Instruction*, (12), 107 -119.

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

Mayer, R. E. (2001). *Multimedia learning*. New York, NY: Cambridge University Press.

Mayer, R. E. (2005a). Principles for managing essential cognitive processing in multimedia learning: Segmenting, pre-training, and modality principles. In R. E Mayer (Eds.), *Cambridge handbook of multimedia learnin*. New Yor, NY: Cambridge University Press.

Mayer, R. E. (2005b). Principle for reducing extraneous processing in multimedia learning: Coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles. In R. E. Mayer (Ed.), *Cambridge handbook of multimedia learning*. New York, NY: Cambridge University Press.

Mayer, R. E., & Moreno, R. (2010). Techniques that reduce extraneous cognitive load and manage intrinsic cognitive load during multimedia learning. In J. L Plass, R. Moreno & R. Brünken (Ed.). *Cognitive load theory*. New York, NY: Cambridge University Press.

Miller, G. A. (1956). The magic number seven plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, (63), 81-97

Moreno, R., & Valdez, A. (2005). Cognitive load and learning effects of having students organizing pictures and words in multimedia environments: The role of student interactivity and feedback. *Educational Technology Research and Development*, (53), 35-45.

Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology*, (91), 358-368.

Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case of minimizing irrelevant sounds in the design of multimedia instructional message. *Journal of Educational Psychology, 92*(1), 117-125.

Nan, J. (2007). Selective integration of linguistic knowledge in adult second language learning. *Language Learning, 57*(1), 1-34.

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive Load theory and instructional design: Recent developments. *Educational Psychologist, 38,* 1-4.

Paas, F., Renkl, A., & Sweller, J. (2004). Cognitive load theory: Instructional implications of the interaction between information structures and cognitive architecture. *Instructional Science, 32,* 1-8.

Pass, F. G. W. C., & van Merriënboer, J. J. G. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive-load approach. *Journal of Educational Psychology, 86*(1), 122-123.

Peterson, L., & Peterson, M. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, (58), 193-198.

Renkl, A., Atkinson, R. K., & Grobe C. S. (2004). How fading worked solution step works—A cognitive load perspective. *Instructional Science*, (32), 59-82.

Seufert, T., & Brünken, R. (2006). Cognitive load and the format of instructional aids for coherence formation. *Applied Cognitive Psychology*, (20), 321-331.

Smith, S. M. (1993). Input enhancement in instructed SLA: Theoretical bases. *Studies in Second Language Acquisition*, (15), 165-179.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, (12), 257-285.

van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, (17), 147-177.

van Patten, B. (1996). *Input processing and grammar instruction: Theory and research*. Noiwood, N. J: Ablex Publishing Corporation.