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

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)


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.


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 \( r = -.151, df = 58, P = .881 > .05 \), 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

<table>
<thead>
<tr>
<th>Types of questions</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Means</td>
<td>Std. deviation</td>
</tr>
<tr>
<td>Cloze</td>
<td>6.6333</td>
<td>1.61850</td>
</tr>
<tr>
<td>Vocabulary &amp; Structure</td>
<td>12.0833</td>
<td>2.32706</td>
</tr>
<tr>
<td>Paraphrasing</td>
<td>11.0333</td>
<td>2.56278</td>
</tr>
<tr>
<td>Translation</td>
<td>13.1333</td>
<td>2.83735</td>
</tr>
<tr>
<td>Writing</td>
<td>14.6500</td>
<td>2.09741</td>
</tr>
<tr>
<td>Total</td>
<td>71.6500</td>
<td>13.96557</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Types of questions</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Means</td>
<td>Std. deviation</td>
</tr>
<tr>
<td>Cloze</td>
<td>6.9833</td>
<td>1.37392</td>
</tr>
<tr>
<td>Vocabulary &amp; Structure</td>
<td>12.8000</td>
<td>1.76459</td>
</tr>
<tr>
<td>Reading Comprehension</td>
<td>13.8000</td>
<td>2.74678</td>
</tr>
<tr>
<td>Paraphrasing</td>
<td>11.2833</td>
<td>3.08970</td>
</tr>
<tr>
<td>Translation</td>
<td>15.2500</td>
<td>2.11216</td>
</tr>
<tr>
<td>Writing</td>
<td>14.6500</td>
<td>2.09741</td>
</tr>
<tr>
<td>Total</td>
<td>74.7667</td>
<td>11.06465</td>
</tr>
</tbody>
</table>

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.

| 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 sentences so 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 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 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.

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