

# A Discussion on the Cognitive Load Management in the Secondary English Education in Japan

我が国の中等英語教育における認知負荷統御に関する論考

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## Introduction

In Japan, there has been a strong call for reformation in English education. There have been calls for radical changes in order to enhance the effectiveness of learning. Scholars, Yoshida (2004), Kanatani (2004), and Takefuta and Suiko (2005) argue the English education has not been effective; and they agree on two problems: (1) the extensive use of instructional strategy has remained unchanged, namely, the Grammar-Translation (GT) method; and (2) the amount of practice to become competent in English is inadequate (Morley, 1990).

To bring about change, more and more English educators have made attempts to apply the findings from the disciplines other than foreign language pedagogy (Kanda, 2001; Diao, Chandler & Sweller, 2007; Kudo, 2014). The present paper is another such attempt to apply the findings from learning science to the secondary level English classrooms; hence the paper looks into the challenges of the application of Cognitive Load Theory (CLT) into the English secondary level classrooms. It then discusses alternative methods of complimenting the existing teaching practice. It is highly expected the cognitive load management

in the classroom can be beneficial in the wide growth of English as a Foreign Language (EFL). Hopefully, CLT enriches English pedagogy that has remained almost unchanged for over half a century.

## **Human Learning and CLT**

### **Human Learning**

The findings of learning science are built upon the theories that human learning can be explained by the construction and automation of schema (Shiffrin & Schneider, 1977) in relation to working memory (Baddeley, 1981) and long-term memory (Newell & Simon, 1972). Miller (1956) clarified our understanding of working memory, highlighting its limitation. Indeed, humans are poor at complex reasoning unless numbers of elements are stored in long-term memory (Sweller, van Merriënboer & Paas, 1998). Only after rehearsal, the processed information is saved in long-term memory. When schemas are available in long-term memory, one coordinates the existing schemas and accomplishes more complex actions.

### **Cognitive Load Theory**

Clark, Nguyen and Sweller (2006) describes cognitive load theory as “a universal set of learning principles” (p.7). A foremost study by Sweller (1988) on CLT puts forth the assumption that a means-ends problem-solving strategy brings about cognitive overload that hinders schema construction, exemplifying by novice learners use of smaller chunk size; frequently use of means-ends

problem solving strategy; and practice of inefficient problem categorization. CLT presumes the learning processes should maintain the cognitive load within the learners' capacity in order for the construction of schema to take place. This particular finding throws into question traditional pedagogy by examining the efficacy of the teacher-centered instruction.

### **The cause of overload: Element Interactivity**

How can we manage cognitive load for the efficient learning? Paas, Renkl and Sweller (2003) explain cognitive overload by "element interactivity" roots from a heavy demand in cognitive process. When the element interactivity of a learning task is high, the essential constructs for understanding are increased, and massive numbers of elements must be processed alongside during learning. Thus, the higher the number of elements to be integrated during execution, the more complicated or difficult a task can be. Within a learning task with high element interactivity, the schema construction can be hindered. The hindrance from high element interactivity can often be observed in the English classrooms throughout Japan. For example, lectures on English reading by GT-method, which premises to hold the required networking elements is supposedly high in element interactivity; hence, cognitive load is overloaded. The long tradition of teacher-centered lessons emphasizing grammar and translation causes intricate mental manipulations, which end up with unproductive schema construction.

### **Three kinds of cognitive load**

For the sake of cognitive load management, it is important to understand the builds of mental load. Van Merriënboer and Ayres (2005) explains cognitive load comprises three constructs: Intrinsic, Extraneous, and Germane. Hereon, each load will be explained along with suggestions for cognitive load management in the classroom for the English education in Japan.

Intrinsic cognitive load stems from the fundamental nature of the learning task and how much a learner can obtain from prior knowledge. The amount of intrinsic cognitive load is defined by the relation between the level of learners' expertise and the level of element interactivity needed to be processed in working memory. In the English classroom, a grammar lecture can be highly rated by the amount of the intrinsic cognitive load. While the level of mastery may be low as the beginning EFL, the interactions that the learners must integrate, such as basic grammatical knowledge, may be extremely high. This readily causes overload. Thus, intrinsic load has been understood as unalterable within instructional interventions; however, the recent studies find the means to moderate intrinsic cognitive load itself by reexamining the learning tasks. A possible means is to dissect a task into constituent skills according to the learners' expertise level, so they can perform a task within their cognitive capacity.

Implications for English education at the secondary schools would be segmenting a grammar lecture into small steps, such as component skills or giving learners the chance to integrate some parts of learning materials before the class because the overload occur from the complex explanation or manipulation of mental

tools that can be damaging for learning. The use of advance organizers will contribute to minimizing intrinsic cognitive load.

Extraneous cognitive load has been discussed in relation with the mental effort that is not directly necessary for learning; therefore, it can be improved by the instructional interventions. Unnecessary cognitive processes stemming from the fictitious design of instructions or faulty learning environment causes cognitive overload, thus the mitigation of an extraneous cognitive load has been the major concern of CLT.

In the secondary English education, visual presentation via computers can avoid unnecessary extraneous cognitive load. There are bunch of instructional resources in the classroom: if a teacher can minimize the learning source into one, learners will be able to stay focused on it by lowing the extra attention. The specific treatments to reduce extraneous cognitive load will be separately discussed and explained with the CLT effects later in relation with implications for English pedagogical approach.

Germane cognitive load is related to processes that are directly relevant to learning such as schema construction and automation. To increase germane cognitive load, the use of worked-out examples and task variability is recommended. Albeit germane cognitive load that does contribute to learning should be increased, and instructors ought to pay attention to overload accumulated, since cognitive load accumulated in the course of learning is additive. Therefore, it is essential for instructional designers to manage the total amount of three distinctive cognitive load factors within the cognitive capacity of the learners.

In summary, CLT provides evidence for the interdependence of

our cognitive architecture, the human learning, and the influence of cognitive load in the learning process, which has been outside the focus of the conventional language teaching practiced in the classrooms. It has become undeniable that the excessive cognitive load brought by the wrongful instructional approaches and arrangements of instruction hamper learning, especially within the secondary education in which learners are at developmental stages. While the study of applied linguistics did not pay adequate attention to the amount of cognitive load during learning, CLT strongly believes that learning happens best under the conditions aligned with learners' cognitive architecture. CLT can offer vital improvements for English education in Japan by reflecting the amount of cognitive load. In the following section, I will discuss suggestions emanating from CLT studies that can be coordinated with secondary English education in Japan.

### **Cognitive load management in English classroom and CLT effects**

#### **Problems of English education in Japan**

The paper presented two difficulties that Japanese English education entails: (1) extensive use of GT method, and (2) inadequate training to be competent to acquire a foreign language. These problems have been commonly observed in the classrooms of secondary English education. As illustrated, the problems persisting in Japan seem to go against the propositions that CLT studies stand on. Also, though it has been obvious that there is a means to solve the problems, there is not enough vicarious connections to implement CLT endorsed strategies. Thus, I take up

the challenge to consider the practical applications of CLT findings to secondary English education.

### **Cognitive load management in the secondary English classroom**

First, the CLT findings can improve one of the two major problems. Clearly, learning of syntax through mere teaching imposes cognitive load owing to high element interactivity. Indeed, it requires learners of morphological cognition, phrase parsing, coordination of semantics, and finally translation. The core pedagogical emphasis on English language in Japan is supposedly demanding of cognitive load, which is more so for the novice learners. Kudo et al. (2003) confirm that this is the case from a series of questionnaires showing that there are increasing numbers of high school students who feel perplexed in their English learning process because of the complexity and difficulty of the subject.

Another problem concerning the use of GT method is the heavy use of the meta-languages in the classroom that heightens the dislike of English. Kudo et al. (2003) reports that beginning level learners who are at the secondary education dislike of English because it uses a lot of jargons and complicated concepts. Although the use of some technical terms and concepts of syntax is perhaps unavoidable in grammar based lessons, the study criticized the oppressive use of the meta-languages and demanding concepts that cause overload. This particular problem may be resolved by a strategy employing visual explanations that can reduce cognitive load in the presentation of the information that CLT suggests.

Kudo (2006) illustrates that CLT driven instructional designs can circumvent another problem in the secondary English education. He suggests the shortage of practice can be improved by using Web-based Instruction (WBI) system. A WBI system is expected to be advantageous in two aspects. WBI can give learners chances to practice outside the classroom via the Internet. Also, under a well-structured WBI system, instructors can easily direct learners' attention on a topic that can avoid reducing excessive extraneous cognitive load. When the point of instruction remains clear and learners can focus their attention on it, the schema construction as well as automation becomes smoother. This, in turn, contributes to attaining germane cognitive load that generates more authentic motivation. Warschauer (1999) argues that the use of WBI promotes language learners' positive participation in a learner-centered environment in which even "demotivated" (Dörnyei, 1998) learners in Japan can also benefit.

I would like to add one more aspect of CLT driven instructional strategy. CLT has been recognized as more effective for beginners or lower achievers rather than experts in what has been called the expertise reversal effect (Renkl, Atkinson & Große, 2004). The EFL learners who often struggle with a beginning level confusion can benefit from CLT driven WBI learning strategy, which have eliminated an unnecessary cognitive load. Combining the face-to-face classes (blended education), beginning level learners can appreciate both humane attention from the instructor and individual attention on WBI system that are capable of timely suggestions and advises.



## **CLT effects**

Finally, the paper discusses the ways to mitigate excessive cognitive load in relation with original CLT findings. The load minimizing strategies will be presented and followed by implications for instructional strategies for the secondary level English education in Japan. The instructional effects in CLT are (a) the goal-free effect, (b) the worked example effect, (c) the completion problem effect, and (d) the split attention effect (Van Merriënboer & Ayres, 2005). Each offers various perspectives of dealing with cognitive load while learning.

Based on the goal-free effect, the problem format asks learners to obtain the subgoals or constituent steps, instead of requiring learners to attain the final goal. Knowing that reaching to each small step to the goal or subgoals (dual-stage effect) can reduce the excessive cognitive load in problem solving, and that it is equally effective for learning. In the case of English reading classes, the goal-free format asks the students to list, for instance, particular noun phrases embedded in a sentence instead of translating complete sentences into the native language, which makes two stages in translation. The two stages allow enough time and space for the learners to maintain cognitive load. Then, the teacher can ask small groups to consolidate the information into a translation. With the dual-stage approach, learners can attain higher rates of correctness in the translation than they can with the whole translation approach.

The worked example effect is about providing a format that describes all solution steps at the initial stage of problem solving. By displaying the procedural solution steps, extraneous cognitive

load can be reduced. The worked examples format particularly has been proven effective in the fields of science, such as mathematics, physics, and geometry, since learners can directly shift their attention on solving processes by heavy use of goal seeking process. In English classrooms, this format has recently been applied by some researchers and found effective (Kyun, Kalyuga & Sweller, 2013; Kudo, 2014). In the studies above, the worked examples have been used as written examples for composition. The students learned the model example in the initial stage, and abstracted out the composition format of English essay as well as expressions used in the worked example. Empirically, the effect of cognitive load reduction was tested by the higher quality of the products and higher complexity in composition (Kudo, 2014).

The completion problem effect can be easily applied to the English classrooms. The instructional format looks similar to the worked example. The difference from the worked example is found in the brackets embedded in the format. Sweller, van Merriënboer and Paas, (1998) points out “the major disadvantage of worked example is that they do not force learners to carefully study them” (p.275). In order for learners to concentrate on learning and acquire schema, the instructional format redirects their attention to what they are learning. Paas (1992) found an advantage for the completion problem format. This technique is also popular in the approach supported by applied linguistics. It is called “brackets”. When the sentence has some empty spaces, the learner can shift their attention to the brackets. Also, filling them in with the proper words can confirm the comprehensive understanding.

The split attention effect also concerns the format of the

worked example. While the completion problem focuses on a pitfall of worked examples, the split attention reveals that the format of example presentation does make a difference in learning efficiency. A comparison between instructional materials information integrated and not integrated finds the integrated version advantageous, which suggests that it is important to not waste cognitive capacity in learning (Paas, 1992). This finding attests that split attention imposes unwarranted cognitive load that interferes with learning. This problem is often observed in conventional Japanese classrooms. The teacher has to pay attention to not only the learning contents and activities, but also multiple learning media existing in a classroom. Split attention on multiple sources (blackboard, textbook, and notebook) dissipates learners' selective attention in the process of learning. In English education nowadays, the students readily become overloaded with the layers of instructive media and ICTs. The teacher should pay through attention on how a student overuses mental effort during the class. Table 1 below summarizes four effects from CLT and representing problem formats and the possible applications for WBI formats for the secondary English education.

Table 1: *The major effects argued in CLT and representing problem formats*

	Example of the CLT driven problem formats
Goal free effect	Find as many noun phrases or the functioning verb as possible in the English sentence below. On WBI, click on the functioning verb.
Worked example effect	Follow the example English paragraph to compose your own. You can use the structure and some of the expressions from the example. On WBI, use the described procedure in the worked examples to compose a simple sentence.
Completion problem effect	Fill in the blank(s) to complete the sample composition formed out of an example. On WBI, put an appropriate word from the multiple choice.
Split attention effect	On the computer screen, follow the procedure of composing a sentence in English. WBI, all instructions and problems are integrated in a one screen.

## Conclusion

The present paper has argued for the viability of the CLT driven instructional strategies for English classroom at the secondary level. As Japanese secondary English education has been chained to the longstanding GT method, it seems to have neglected the arguments related to learners' cognitive capacity while engaged in learning. Further consideration to the human cognitive capacity should be part of the picture of our envisioned English language classroom. The CLT-endorsed instructional strategies also have much to offer to salvage "demotivated learners or English dislikes" in the secondary schools. The new educational interventions, such as WBI and blended learning environment coupled with CLT

principles, may suggest a direction for the recovery of learning motivation.

The paper has put emphasis on the importance of learners' cognitive resource to be redirected on a targeted topic of learning in order to facilitate schema construction. The proposed strategies attempt to enable learners to focus on a simple cognitive action in learning process. Upon achieving linguistic competence, the beginning level EFL learners need to incorporate numerous sets of cognitive skills. In the present paper, I proposed WBI that the students can focus on acquiring the decomposed skills that have been dissected into lower categories. Albeit not on computers, adding skill-based practices, students can construct their schema by incorporating the previously acquired knowledge and present learning. Also, the multiple practices of sub-skills are expected to be beneficial in acquiring and incorporating the newly learned schema. Using the ICT technologies, the practice becomes simple for the beginners to construct the primary schema for language, and this in turn increases germane cognitive load. I hope CLT endorsed leaning strategies gains more popularity and creates better learning environment for English learners at the secondary level in Japan.

### **References**

- Baddeley, A.D. (1981). The concept of working memory: A view of its current state and probable future development. *Cognition*, *10*, 17-23.
- Clark, R., Nguyen, F., & Sweller, J. (2006). *Efficiency in Learning*:

- evidence-based guidelines to manage cognitive load*. Pfeiffer: San Francisco, CA.
- Diao, Y., Chandler, P., & Sweller, J. (2007). The effect of written text on learning to comprehend spoken English as a foreign language. *American Journal of Psychology*, 120(2), 237-330.
- Dörnyei, Z. (1998). *Demotivation in foreign language learning*. Paper presented at the TESOL '98 Congress, Seattle, WA, March.
- Kanatani, K. (2004). *Koukou eigowo kaeru wayaku sakiwatashi jugyono kokoromi* [A trial of early handout of Japanese translation to change English education at high schools]. Sanseido: Tokyo.
- Kanda, S.T. (2001). *Applying cognitive load theory to second language acquisition*. Unpublished Doctoral Thesis, University of New South Wales, Sydney.
- Kudo, M. (2006). Design of Web-based cognitive learning strategy (Single Cognitive Sub-skill Drills: SCSD) for English remedial instruction. *Proceedings of the 22nd annual conference of JSET*, 1107-1108.
- Kudo, M., Ohbuchi, K., & Matsui, M. (2003). The collaboration between Information Technology and English -- an interdisciplinary approach for developing CALL application. *The Bulletin of SSTA*, 12, 57-65.
- Kudo, M. (2014). *Effects of Worked Examples on Stress, Cognitive Loads, and Performance in Online Collaboration*. Unpublished Doctoral Dissertation submitted to International Christian University.
- Kyun, S., Kalyuga, S., & Sweller, J. (2013). The Effect of Worked Examples When Learning to Write Essays in English Literature,

- The Journal of Experimental Education*, 81(3), 385-408.
- Miller, G.A. (1956). The magical number seven, plus minus two: Some limits on our capacity for processing information. *Psychological Review*, 14, 263-264.
- Morley, J. (1990). *Trends and Developments in Listening Comprehension: Theory and Practice*. Georgetown University Round Table on Languages and Linguistics. 317-337.
- Newell, A., & Simon, H. (1972). *Human problem solving*. Englewood Cliffs, NJ. Prentice Hall.
- Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive Load Theory and Instructional Design: Recent Developments. *Educational Psychologist*, 38(1), 1-4.
- Paas, F. (1992). Training Strategies for Attaining Transfer of Problem-Solving Skill in Statistics: A Cognitive-Load Approach. *Journal of Educational Psychology*, 84(4), 429-434.
- Renkl, A., Atkinson, R.K., & Große, C.S. (2004). How fading worked solution steps works: A cognitive load perspective. *Instructional Science*, 32, 529-556.
- Shiffrin, R., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review*, 84, 127-190.
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12, 257-285.
- Sweller, J., van Merriënboer, J. & Paas, F. (1998). Cognitive Architecture and Instructional Design. *Educational Psychology Review*, 10(3), 251-296.
- Takefuta, Y. & Suiko, M. (2005). *Korekarano Daigaku Eigokyouiku* [The

- Prospective English education in Japan]. Iwanami Pub: Tokyo.
- Van Merriënboer, J., & Ayres, P. (2005). Research on Cognitive Load Theory and Its Design Imprecations for E-Learning. *Educational Technology Research and Development*, 53(3), 5-13.
- Warschauer, M. (1999). *Electronic literacies: Language, culture, and power in online education*. Lawrence Erlbaum Associates: Mahwah, NJ, USA.
- Yoshida, K. (2004). *Eigoga tsukaeru nihonjinn” no ikuseino tameno eigokyouin kenshu guidebook* [A guidebook for teacher trainings to raise “Japanese who can use English”]. Kairyudo: Tokyo.