

Cognitive Load Theoryの日本における外国語としての英語教育を改善するための概念的, および応用手法 Cognitive Load Theory (CLT) as a Conceptual and Practical Means for Improving English as a Foreign Language Education in Japan

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ABSTRACT

本論文は、認知負荷理論から生成された教授方略を用いながら、どのように学習科学の知見を我が国のEFL教育に応用するか議論する。近年の研究成果は、我が国のEFL教育に対して有効性の乏しさを問題として指摘しており、多くが文法翻訳法に代表される伝統的な言語教授法の継続的な使用、ならびに、学習者中心の訓練不足に問題があるという点で一致している。本論は、従前からの伝統的な客観主義教育理論に依拠するEFL教育に大きな変革が必要であることを説明し、近年の認知負荷理論から得られた知見をEFL教育に補完する可能性について吟味する。

The paper will argue how cognitive load theory (CLT) driven instructional strategies can be applied to the field of EFL education in Japan informed by achievements from the learning science. Recent studies have criticized EFL education in Japan for its ineffectiveness and many agree with the persisting use of traditional language pedagogies, such as the Grammar-Translation method and inadequate amount of learner-centered training. The paper illustrates the need for a substantial change in EFL education that still depends upon traditional objectivism-oriented pedagogies. Recent findings from CLT discuss the possibility of compensating for such a deficiency in Japanese EFL education.

1. Introduction

Helgesen (1991) laments the ineffectiveness of English education in Japan that a great number of college students cannot even carry on a simple conversation in English. Nakamura (2005) studied an increasing population of college students who remained incompetent despite the compulsory English education, and called them ‘false beginners’. A body of research (Asher, 1972; Morley, 1990; Kanatani, 2004; and Takefuta & Suiko, 2005, etc.) agrees on two dilemmas presented by Japan’s English as a Foreign Language (EFL) education: the extensive use of traditional instructional strategy based on a knowledge-based instructional paradigm heavily influenced by objectivism, referred to as Grammar-Translation method (GT method); and inadequate amount of learner-centered training to promote practical linguistic competences.

Recently several researchers began exploring a new frontier by applying the findings from educational technology to foreign language instruction (Diao, Chandler, & Sweller, 2007; Kudo, 2007; Kanda, 2001). Cognitive Load Theory (CLT) (Sweller, 1988) is particularly gathering attention hoping to solve problems and devise more effective and learner-centered instructional approaches. The strategies developed by educational psychology will provide vital suggestions to EFL instruction that still relies on objectivism-oriented instructional strategies.

This paper examines the achievements of research on CLT to develop an in-depth understanding of human cognitive architecture and the act of learning in relation with the human information storage system. It is hoped to be the solid base for a change in Japanese EFL instruction. Then, it discusses the challenge of applying the findings from CLT to the field of EFL within the blended learning contexts for false beginners of EFL.

2. Basic assumption: CLT and human learning and information storage

CLT has been developed upon the premise that human cognitive architecture can be theorized as the development or construction of schema (e.g., Bartlett, 1932) in relation to working memory (e.g., Baddeley, 1981), long-term memory (e.g., Newell & Simon, 1972) and automation of schema (e.g., Shiffrin & Schneider, 1977). Miller (1956) clarified the characteristics of working memory by emphasizing its limited capacity. The limitation in working memory signifies “humans are particularly poor at complex reasoning unless most of the elements with which we reason have previously been stored in long-term memory” (Sweller, van Merriënboer & Paas, 1998; p. 254).

Research on CLT has revolved around instructional designs to minimize cognitive load or mental effort upon schema construction when dealing with novel information (Clark, Nguyen, & Sweller, 2006). According to the schema theory by Gick and Holyoak (1983), information is first processed and rehearsed in the working memory, after which it is saved in the long-term memory as schemas or schemata. “Schemata are cognitive constructions that help to reduce the cognitive burden on working memory, because they allow categorizing multiple elements of information as a single element” (Schnotz & Kürschner, 2007; p.475). One can accomplish more complex actions when schemas are available and coordinated.

Van Merriënboer and Ayres (2005) justify CLT as a model to yield efficient learning and instructional design principle based on the human cognitive architecture. Clark et al. (2006) describe CLT as “a universal set of learning principles that are proven to result in efficient instructional environments as a consequence of leveraging the human learning processes” (p.7). Hence, learning occurs when cognitive load is contained within the limits of

one's cognitive capacity. Accordingly, CLT provides implications for instructional designers to realize efficient construction of schema in relation with human cognitive capacity.

3. The concept of CLT and instructional strategies

A study on novice learners by Sweller (1988) reexamined the importance of schema acquisition. The work outlined three major characteristics of novice learners: (1) smaller chunk size, (2) frequent use of means-ends problem solving strategy, and (3) inefficient problem categorization. It confirmed that the conventional problem solving approach, based on knowledge-based instruction, does not promote schema acquisition. Selective attention and cognitive processing capacity (Sweller & Levine, 1982) were emphasized to explain the interference with problem solving instruction, hence the results led him to conclude means-ends problem solving strategy generates greater cognitive overload.

In a series of experiments Sweller (1988) explained the interdependence of the human learning, cognitive functions and schema construction and found a group using a reduced cognitive load problem format demonstrated fewer mistakes and quicker performance compared to a group using the conventional format. He further explained that problem solving by means-ends analysis and the attempt to acquire schemas are distinct actions. Taking two actions simultaneously generated overload, which later was named the "dual-task paradigm." He used 24 students of the 10th grade, asking them to solve 6 trigonometry problems using distinctive problem formats and required them to remember. The results suggested interference generated by increased cognitive load from the dual-task and more capacity for learning may be available via the reduced cognitive load format. In the following section, I will look into various arguments of CLT.

3. 1 Further development of CLT research

Scholars agree that cognitive overload is due to excessive demand resulting from the design of learning tasks. Paas, Renkl and Sweller (2003) uses a term, "element interactivity," to explain the heavy cognitive demand. They hypothesize that tasks learners execute may vary in spectrum from low to high in element interactivity that brings about the complexity of a task, thus in turn, high cognitive load. When element interactivity is high "[e]lements interact and must be processed simultaneously for understanding and learning to occur" (Sweller, 2003; p.218). The number of information components for processing dictates the level of element interactivity.

The further research on cognitive load has identified cognitive load should be distinguished threefold: intrinsic, extraneous, and germane. Intrinsic cognitive load is brought about by the intrinsic nature of the task. The amount of intrinsic cognitive load is, therefore, determined by the interaction between the learners' expertise level and the number of element interactions. Thus, the past research perceived intrinsic load as fixed. For this reason, the manipulation of intrinsic cognitive load has been excluded from CLT studies for an extended period of time. However, the new trend in CLT studies attempts to reduce intrinsic cognitive load by reexamining the learning tasks (c.f. Pollock, Chandler, & Sweller, 2002; Kudo, 2007).

Extraneous cognitive load is associated with cognitive processes that, while not directly necessary for learning, manifest due to the complicated design of instructions or faulty learning situations; therefore is subject to instructional intervention. Discussed in the previous chapter, the reduction of excessive extraneous cognitive load in learning has been the prime concern of CLT studies, thus the six effects illustrated in the next section are meant to reduce the extraneous load.

Germane cognitive load is associated with processes relating directly to learning, schema

construction and automation. Recent studies aimed at sustaining a high level of germane load have gained popularity (Beckmann, 2010; Paas, & van Gog, 2006). Germane cognitive load should be increased, without causing overload. Therefore, it is essential for instructional designers to manage the total amount of cognitive load to be within learners' cognitive capacity.

3. 2 Six instructional strategies driven from CLT research

Van Merriënboer and Ayres (2005) categorized six CLT-driven effects: (1) the goal-free effect, (2) the worked example effect, (3) the completion problem effect, (4) the split attention effect, (5) the modality effect, and (6) the redundancy effect. CLT studies evolved around these problem formats, and each offer a unique perspective on cognitive load for the instructional strategies.

The goal-free effect attempts to reduce excessive cognitive load in problem solving without requiring learners to reach a goal. Instead of reaching goals, the goal-free format asks learners to list the required variables (or subgoals). Ayres (1993) studied 67 grade school students to compare the effect of format in geometry, requiring one group to "find all unknown angles" and another to reach a final goal. The goal-free format group displayed superiority in correct answers, accuracy of goal-attainment in the dual-stage and with regards to the frequency of errors in the sub-goal stage.

The worked example effect deals with an instructional format that provides learners with solution steps. Demonstrating the complete problem solving procedure contributes to the reduction of cognitive load. Reisslein, Atkinson, Seeling, and Reisslein (2006) observed the benefits of three different computer-based learning environments, in which worked examples were followed after by similar problems; problems followed after by worked examples; and a fading problem format

where worked examples faded away. They found the example-problem format advantageous for lower achievers, while the problem-example format effective for higher achievers. This finding became a basis for the hypothesis of the expertise reversal effect (Reisslein et al., 2006; Kalyuga, Ayres, Chandler, & Sweller, 2003) and the worked example effect.

The completion problem effect applies an analogous idea to the worked example. The completion problem format includes several brackets embedded in the worked examples. Sweller, van Merriënboer, and Paas, (1998) argued "one major disadvantage of worked example is that they do not force learners to carefully study them" (p.275). For learners to acquire schema, the instructional format needs to redirect their attention onto what they learn. Paas (1992) compared the three problem formats: conventional, worked example, and completion problems; subsequently, confirmed the advantage of completion problem format in performance, transfer, and the amount of cognitive load. Ultimately he claimed redirecting learners' attention on the learning topic attained the best results.

The split attention effect concerns the presentation of worked examples. While the completion problem is to redirect learners' attention on the format of worked examples, the split attention effect tries to explain how the presentation of the example should be integrated for optimal learning. Sweller et al. (1998) exemplified two diagrams of geometry problems. One format was called "integrated version", which integrates information in one unit. Another included an isolated diagram and instructions underneath; the latter part of the example appeared to be the second section of instructions. They found the integrated version to be effective, in comparison with others despite the minor alteration in design, and thus the split attention effect imposes unwarranted cognitive load during learning.

The two remaining effects, modality and

redundancy effect, are based on findings that information is processed within the multi-apparatus: the phonological loop (Baddeley, Gathercole & Papagno, 1998) and the visuospatial sketchpad (Baddeley, 2002). Hence, information should be either integrated or discretely presented according to the task difficulty and learners' level of expertise, otherwise instructional information presented by the different source will hamper learning.

4. CLT-driven strategies for EFL

As seen in the previous chapters, CLT research has been fairly limited to the well-structured fields, such as physics, and geometry, while fewer studies attempted to apply CLT findings to ill-structured fields (Rourke & Sweller, 2009; van Merriënboer, 1997). Despite the recent development, CLT findings are still seldom applied to EFL.

4. 1 Implications of CLT applications for EFL false beginners

Kanda (2001) was so far the most comprehensive application of CLT findings into EFL pedagogy focusing on the limited cognitive capacity of beginning learners. It contributed to both fields by showing alternative designs to administer CLT effects into EFL. It examined the findings on modality effect, its replication, and on split attention effect from CLT for Thai EFL learners to teach passive voice. The investigation of an experimental design to teach conversion of voices revealed effectiveness of modality effect and integrated version; then concluded CLT driven instructional design was advantageous in schema construction and transfer for EFL learners.

Diao and Sweller (2007) was an attempt to apply a method of information presentation to the language pedagogy from CLT studies. It examined the redundancy effect on reading comprehension in the context of EFL using written and spoken

presentations, and investigated the effect of dual presentation of linguistic input. They compared the learners' comprehension and found that, where intended to evaluate the level of comprehension, the use of a full script or subtitles upon listening showed detrimental effects on the construction and automation of schema for comprehension. It was assumed that the additional information through the visuospatial sketchpad became extraneous and caused overload.

The present EFL education in Japan seems to be in opposition to recent CLT findings in many aspects. Even though a body of research agrees upon the importance of the communicative approach to justify the use of the target language, it is difficult for EFL learners, especially at the beginning stage, to objectify a foreign language as a communicative tool due to lack of and the complexity of grammatical codes. It is obvious, from a CLT point of view, how beginning EFL learners suffer from massive overload when dealing with multiple levels of crude grammatical codes. This should be a major reason why communicative language approach in Japan is not successful. Furthermore, this elucidates a condition for false beginners in which there is no particular imperative to use English.

4. 2 Collaborative work using worked examples

The present paper proposes an instructional strategy for beginning level EFL learners in Japan. A scaffolded collaborative learning (Jung, Kudo, & Choi, 2011) can be recommended for the sake of pursuing the reduction of excessive cognitive load, practical use of a target language and learner-centered learning environment for meaningful interaction. Collaboration can be a means to facilitate group learning (Johnson & Johnson, 1999), in which multiple participants work synchronously and interactively on a joint solution to a problem (Dillenbourg & Schneider,

1995). Recent studies (Kirschner, Paas, & Kirschner, 2008; Schnotz & Kürschner, 2007) hint at the implications of lessening cognitive load through collaborative learning by sharing responsibility with members in collaboration. Kirschner et al. (2008) suggests the possibility of less cognitive demand by distributing cognitive effort among the participants. By integrating less competent students with more advanced peers in a learning community, the collaborative learning could assist learning, especially that of learners with diverse backgrounds and experiences (Gerlach, 1994).

Worked examples can support meaningful collaboration as a scaffold for beginning learners. Without such support, beginning level learners cannot accomplish the tasks. The provision of well-written examples for composition tasks are recently confirmed effective for supporting deficiency in literal competency (Schworm & Renkl, 2007; Rourke & Sweller, 2009; Hübner et al., 2010). Renkl, Hilbert, & Schworm (2009) illustrates a new type of worked example, which includes the structural support and composition. By observing a well-written composition on each part of a composition along with structural tips, learners can borrow the structure and ideas that reduce cognitive load during the composition task, and consequently model off the example for their own work (Schworm & Renkl, 2007).

An online collaborative composition project could be appropriate as a classroom task for EFL beginners. Recent development of LMS realizes peer collaboration outside the class. Using wiki and forum installed in the LMS provides learners with learner-centered learning experiences. Hübner et al. (2010) exemplifies the usage of a written model for collaborative work. The worked example should include exemplary logical organization, illustration or support of ideas, analysis of problems, and appropriate choice of words and clear expressions. With worked examples as scaffold, beginning

EFL learners can enhance learning in and among themselves in and out of classes in the blended learning environment. Provided with a model composition on the same topic as a worked example, peer interaction in the collaborative learning can be enhanced and expected to be effective.

5. Conclusion

The paper initially illustrated the development and various effects of CLT research, and examined CLT-driven instructional strategies for EFL education. With the adoption of the Grammar-Translation method, Japanese EFL education has neglected the importance of learners' cognitive capacity in the process of foreign language learning. This paper argued that especially at the beginning stage, more close attention to the human basic cognitive capacity should be paid to improve any second or foreign language learning, and CLT-driven instructional strategies can provide valuable suggestions for EFL education in Japan, which has remained substantially unchanged for 50 years. Advanced digital technologies can also be a help to realize new instructional strategies for EFL learning. The discussion concludes by proposing online collaborative composition projects assisted by worked examples for the future possible application of CLT driven instructional strategy.

Online collaboration can be a means to minimize the detrimental effect of EFL instruction. Generally speaking, online collaboration can realize an ideal learner-centered learning condition by working towards common aims. It allows participants to share collective knowledge, experience, skills and resources (Jung, Kudo, & Choi, 2012). Proper scaffolds, including worked examples and mutual peer assistance, would enable the reduction of cognitive load during learning, and guide Japanese EFL learners to be more independent

and autonomous in regards to their own learning, which in turn yields deeper learning. Borrowing the external information provided by others creates an extra resource for task completion without overloading one's own cognitive capacity. Combined with worked examples, peer interaction in the collaborative learning experience can enhance effective learning, even for false beginners of Japanese EFL. Such a constructivistic learning environment should be an alternative for EFL learners still remaining at the beginning level.

It is advisable to pay more serious attention to existing false beginners of EFL by avoiding the traditional objectivism-oriented design that provokes a means-ends problem solving process. CLT warns about the intricacy of element interactivities, and indicates how to avoid them. It may be helpful to reconsider the initial stage of instruction. Since grammar instruction can be very complicated for beginning level learners, an attempt can be made to decompose grammar instruction so that learners can manage to distribute their cognitive resource (Kudo, 2007). This synchronizes with the idea of dissecting the element interactivity discussed in chapter 3. Nonetheless, the implementation of CLT findings into foreign language pedagogy in Japan is at its genesis, with hope that the future will bring with it suitable applications.

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