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Reducing Cognitive Load using RLOs with Instructional Strategies

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Abstract— This study explores the effectiveness of Reusable Learning Objects (RLO) integrated with two instructional strategies to reduce cognitive load as measured by the Paas mental effort rating scale. The main intention for utilizing the RLO strategy is to create smaller chunks of information to help reduce cognitive load, thus enabling incremental consumption of processed information as advocated in a constructivist environment. The RLO strategy has illustrated similar-functionality of the working memory as indicated in the Cognitive Load Theory (CLT). The information delivered through two different instructional strategies with the incorporation of the RLO was expected to enhance learning with the reduction of cognitive load as learning progressed. However, does the reduction of cognitive load really reduce the mental effort invested by learners during the learning process? The subject matter selected for the RLO strategy was the Malaysian Form One English Literature Component. There were 160 subjects who participated in this study. Participants self-rated themselves using the Paas mental effort rating scale to measure their mental effort investment in their posttest. The results showed no statistically significant differences of the mental efforts between the groups of students following both instructional strategies. However, the effectiveness of the instructional strategies may potentially help reduce extraneous cognitive load.

Index Terms— Cognitive Load Theory (CLT), Constructivist Learning Environment (CLE), Instructional Strategies, Instructivist Learning Environment (ILE), Mental Load, Mental Effort Rating Scale, Reusable Learning Object (RLO).

1 INTRODUCTION

EDUCATION reforms in tandem with the enhancement of technology have exposed Malaysian students to the latest technology devices and resources [1]. The Malaysian government has provided various types of digital learning objects mainly in the form of CD-ROMs to assist classroom teaching. The Malaysian ETeMS (English for Teaching Mathematics and Science) policy had advocated strongly the use of technology within the Malaysian school learning environment. One of the main goals of this Malaysian Government policy was to improve the English language proficiency among Malaysian students. The low English proficiency and negative attitudes towards learning English among the Malaysian second language (L2) learners have necessitated investigations for enhancing English learning through cognitive load reduction [2].

The main principle of the RLO strategy is to produce smaller chunks of information that can be reused in various learning contexts. At the same time, the development of reusable learning objects (RLO) utilizes the break and reassemble criterion. Specifically, the RLO is a desirable strategy used to help reduce cognitive load with the incremental usability of various small informative chunks to facilitate learning. The effectiveness of the RLO strategy integrated with instructional strategies in teaching English as second language has yet to be the focus of Malaysian educational research.

The present study was conducted within the context of creating a technological learning environment in learning English as a second language for the Malaysian students. The learning context of a second language in Malaysia focuses on the examination genres rather than the learners' ability to acquire language skills [3]. Therefore, students only learn according to the teacher's guidance to enable better alignments with the examination genres in order to attain higher scores. Basically, the selective information delivered by teachers mainly focuses on language learning in practice rather than language acquisition. This selective method for language learning has limited the vocabulary literacy among the L2 learners. Subsequently, the limitation of vocabulary literacy of the L2 learners has a direct influence on the level of English proficiency. In order to improve the level of proficiency, teachers should be aware of the importance of language acquisition instead of just language learning as supported by Yang's [4] research which concluded that language acquisition is more important than language learning in practice.

With regard to cognitive load theory (CLT), the present study was designed to investigate the mental effort investment in the test performance using the Paas [12] mental effort rating scale. The research framework assumed that the designed instructional strategies were able to reduce cognitive load through the adaptability of RLOs.

The research question formulated was *"Is there a difference for mental effort rating scales between students following the two instructional strategies?"*

The null hypothesis is derived from the prediction that there is no significant difference in the mental effort rating scales between students following the two different instructional strategies.

The design of the RLOs was based on the CISCO RLOs Model. The theme of reusability has initiated the reusable information objects (RIO) strategy. According to the Cisco System [6], RLO strategy is built upon the RIO. The RIO is a gra-

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nular reusable chunk of information that is media independent. The RIO is developed once but can be delivered in multiple delivery mediums. RIO is a stand-alone component with the combination of content items, practice items and assessment items which are designed base on a single learning objective. The RIOs are then combined to form a larger structure called the Reusable Learning Object (RLO). A RLO is created holding five to nine (7 ± 2) RIOs as Figure 1 depicts. A RLO is authored base on a single learning objective. Each RIO in the RLO supports the RLO's objective which is derived from specific job task. The developed RLO has illustrated similar functionality within a working memory system.

However, the digital RLO will not effectively stimulate learning without the integration of instructional strategies. Instructional strategies incorporated with the RLO strategy are delivery approaches used to transmit information effectively. Therefore, integrating RLO with the instructional strategies will be investigated. The Paas mental effort rating scale was used to analyse the students' mental effort invested during the posttest performance. The comparison of the mental effort rating scales between learners of both instructional strategies were analysed to evaluate the effectiveness of the RLO with two different instructional strategies in reducing cognitive load.

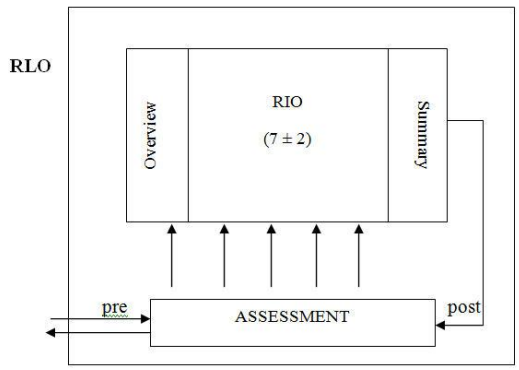

Fig. 1. The Reusable Learning Object Strategy (Adopted from CISCO System, 1999)

Learning is often related to the level of cognitive processes within the learner's brain cognitive architecture. Different learners comprehend the information delivered differently within their own cognitive system. Therefore, the cognitive load theory should be one of the major considerations when investigating how learners interact and manipulate the information from every subject domain presented. Cognitive load theory (CLT) suggests that learning happens best under conditions that are aligned with the human cognitive architecture [7]. Human cognitive architecture is held to consist of a limited-capacity working memory and an unlimited-capacity long term memory [8]. The working memory deals with the independent subcomponents of the auditory/verbal material and visuals (2 and 3 dimensional) information [7]. Working memory can store up to seven elements at a time but operationally process only two to four elements simultaneously [9]. Elements of information are being processed, extracted and manipulated in the working memory to construct schemas then transferred and stored in the long term memory.

CLT is concerned with techniques to manage working memory load through schema construction and automation in order to facilitate changes in long term memory [7]. Working memory load is affected by intrinsic, extraneous and germane load. With regard to human cognitive system, CLT has been concentrating in the management of total cognitive load imposed by learning activities. Intrinsic cognitive load refers to the number of interacting information elements the material contains [8]. The load imposed by the manner in which the information is presented to learners and by the learning activities required by learners are called extraneous and germane load. Extraneous or ineffective load is imposed by information and activities that do not contribute to the processes of schema construction or automation. Germane or effective load is related to information and activities that foster these processes [7].

Intrinsic cognitive load is considered unalterable by instruction as it is largely determined by element interactivity, but several research has proposed instructional techniques to manage this load [7],[8],[10]. In conjunction to reduce cognitive load, reduction of extraneous cognitive load will be an important consideration when designing instruction or learning materials [7],[11]. In order to aid cognitive capacity, reducing extraneous cognitive load to the lowest level during the learning process and increasing germane cognitive load will affect the effectiveness of the instructional environment.

Primarily, instructional strategies designed are meant to improve the reduction of extraneous load and increment of germane load through pedagogical dimension. In addition, the implementation of the RLO strategy was to investigate the reduction of intrinsic load which has been stated as an unalterable load. Incorporation of the RLO strategy into the instructional strategies will be expected to help the learners reduce cognitive load and create a meaningful learning environment.

2 METHODOLOGY

Data was collected from a sample consisting of 160 students. The sample was selected and assigned randomly in groups. Participants were from four different schools in the same district and were divided into two subgroups which were then administered with two different instructional strategies. This study employed the pretest-posttest control group design to measure learners' mental load using the Paas mental effort rating scale. The two groups were the experimental group which was administered with the Constructivist Learning Environment (CLE) and the control group which was administered with the Instructivist Learning Environment (ILE) simultaneously for a period of 4 weeks. The mental effort rating scale was measured using ordinal scale in order to rank the level of mental effort invested by students during the posttest.

The tests developed by the researchers were reviewed by two senior English teachers having more than twenty years of

experience in teaching English. The review was to ensure the content and construct validity of the tests. The reliability coefficient of Cronbach's alpha was 0.869 for the pretest items and 0.867 for the posttest items resulting from a pilot study. The mental effort rating scale was obtained from the Paas [12] Cognitive Load rating scale. The rating scale was ranked from the lowest number to the highest number according to the load of mental investment. The rating scale was ranged from 1 = very, very low mental effort to 9 = very, very high mental effort. Students were asked to rate themselves during the posttest after the treatment.

The learning environments designed in this study were based on the constructivist and instructivist strategies. The CLE had adapted the proposal of story problem solving by Jonassen [13] and the ILE was based on the Hunter's Design of Effective Lessons Model [5].

The ILE lesson protocols comprised of three major components to deliver the RLO developed. The introduction of learning objectives and overview learning tasks was the initial step. The main presentation was the crucial session for knowledge transfer. Learners absorbed knowledge presented through various components of RIOs and RLO. Learners were guided actively to use the practice items developed. Corrective feedback was important to provide immediate response during the teacher-students discussion.

The CLE utilised the student-centered pedagogy where students explored for information and discovered knowledge using the story problem solving method [13]. Students interacted with the RLO. During the interactivity between the RLO and the learners, learning occurs through sessions of discussion of problem statements, identifying the problems, selecting the appropriate information and plan for solutions. Lastly, self-evaluations with their peers were carried out before the teacher's evaluation. This strategy applied the guided-discovery approach with a facilitator ensuring students stayed on the right track during the learning process.

3 Results

The one-way ANOVA (Analysis of Variance) was used to determine the significant differences between the mental efforts rating for the tests. The results revealed that there was no significant differences of mental efforts between students following the two instructional strategies with the probability value of $p = 0.135$. Therefore, the null hypothesis was failed to be rejected.

4 Discussions

The result of this study failed to reject the null hypothesis as there were no significant differences of the mental effort rating scales between the two different instructional strategies. Pragmatically, students rated their mental burden themselves after performing the tests. The instructional strategies and RLOs may have resulted with a higher element interactivity which indirectly imposed higher intrinsic load during learning and test performance. There is also a possibility of higher extraneous load imposed by the learner-centric activities in the CLE where students of limited proficiency suffered overload in their working memory system. Students may have to deal with too many unfamiliar words with their limited vocabulary. Therefore, the English language may have imposed a higher intrinsic load that caused higher mental effort investments in this study.

In conjunction, the mental effort measured and the performance may have also visualised the instructional efficiency. The relationships between the dependent variables (posttest and mental effort rating scale) were examined by utilizing Pearson's correlation analysis. The results showed that the overall correlation between the two dependent variables was significant at the level 0.05 ($r = -0.205$, $p = 0.009$). The results also indicated a statistically significant negative correlation between the mental effort rating scales and the posttest scores. The negative correlation illustrated that the students of lower test score invested higher mental effort and vice versa. This finding is in line with Paas et al. [15] that identified the negative correlation between performance and mental effort measure. These results may indicate and represent a significant measure on the instructional efficiency of the strategies utilized. In relation to the instructional efficiency, these findings also indicated that the ILE was found to be more efficient than the CLE. It was consistent to Paas et al. [15] indicating that higher efficiency occurs when the mental effort investment is lower. The mean difference of the mental effort rating scales between students of the CLE and the ILE was 0.436. Therefore, the students' mental effort investment was found lower in the ILE compared to students following the CLE illustrating that instructionism seems to be a more efficient strategy than constructivism.

Learning English as second language may represent a high cognitive load for most of the Malaysian students as the main medium of instruction is the Malay Language. Illustration of the CLT into the RLO strategy helps students to deal with smaller informative chunks from larger pieces of information. However, results of this study revealed that there was no reduction of mental effort investment after the treatments were administered. Additionally, the mental effort invested during the test performance could be due to higher interactivity of the information elements within the RLO which imposed greater intrinsic load [8]. Therefore, it is possible that the mental effort rating scale shows no difference of mental effort investment after dealing with more RIO during their test performance. Indeed, the various RIOs in the RLO could have possibly created a more complex learning context after the process of selection and using the learning objects delivered. Specifically, the RLO strategy has the possibility to stimulate a complex learning environment among L2 students that will help to improve language acquisition.

In terms of generalization, there are some limitations. First, the study was limited to the Malaysian Lower Secondary One (Form One) students. The results of this study may not be generalized for the Upper Secondary level. Second, the study was also limited to only a short story of the Form One English Literature Component. Lastly, the intrinsic load was not considered in the study. Therefore, further investigations should be carried out in future to analyse the intrinsic load for other

English language skills among the Malaysian L2 students at different school levels.

5 Conclusion

The present study provides findings of the mental effort investment of students learning English as second language after the incorporation of the RLO strategy with two instructional strategies. The expectation of reduced cognitive load was not supported as no differences were obtained from the mental effort rating scale after the treatments were administered. However, there is a possibility that after the RLO strategy was incorporated in the instructional strategies provided positive influences on intrinsic load. This was proven by the negative correlation between the posttest scores and the mental effort rating scales. The level of interactivity cannot be determined by merely analysing the instructional material. Different individuals are capable of interpreting and transmitting the knowledge obtained differently. A large number of interacting elements for one person may be a single element for another person with more expertise [14]. Therefore, the task difficulties and the learner's expertise should be taken into consideration for further investigation.

References

[1] I. Hamzah, A. Ismail, A.H. Tamuri, M.A. Embi & A.L. Maimun, "The Emergence of New Technology in Malaysian Smart Schools: Views of Islamic Education Teachers and Students," *The International Journal of Learning,* vol. 16, no. 4, pp. 249-262, 2009.

[2] S.M. Thang, S.L. Ting & Jaafar, N.M., "Attitudes and Motivation of Malaysian Secondary Students towards learning English as s Second Language: A Case Study," *The Southeast Asian Journal of English Language Studies,* vol. 17, no. 1, *pp.* 40-54, 2010.

[3] K.E. Tan & J. Miller, "Writing in English in Malaysian High Schools: The Discourse of Examinations," *Language and Education,* vol. 21, no. 2, pp. 124-140, 2007.

[4] H. Yang, "On teaching strategies in second language acquisition," *US-China Education Review,* vol. 5, no. 1, pp. 61-67, 2008.

[5] S.G. Magliaro, B.B. Lockee & J.K. Burton, "Direct Instruction Revisited: A Key Model for Instructional Technology," *Educational Technology Research &Development,* vol. 53, no. 4,pp. 41–55, 2005.

[6] Cisco Systems, *Reusable Information Object Strategy: Definition, creation overview, and guidelines*. San Jose, CA: Cisco Systems, Inc, 1999.

[7] F. Paas, A. Renkl & J. Sweller, **"**Cognitive Load Theory: Instructional Implications of the Interaction between Information Structures and Cognitive Architecture," *Instructional Science,* vol. 32, pp. 1–8, 2004.

[8] T. Van Gog & F. Paas, "Instructional Efficiency: Revisiting the Original Construct in Educational Research," *Educational Psychologist,* vol. 43, no. 1, pp. 16–26, 2008.

[9] J.J.G. van Merrienboer & J. Sweller, "Cognitive Load Theory and Complex Learning: Recent Developments and Future Directions," *Educational Psychology Review,* vol. 17, no. 2, pp. 147-177, 2005.

[10] E. Pollock, P. Chandler & J. Sweller, "Assimilating complex information," *Learning and Instruction,* vol. 12, pp. 61–86, 2002.

[11] J. Sweller, "Cognitive Load Theory, Learning Difficulty and Instructional Design," *Learning and Instruction,* vol. 4, pp. 295-312, 1994.

[12] F. Paas, "Training Strategies For Attaining Transfer Of Problem-Solving Skill In Statistics: A Cognitive-Load Approach," *Journal of Educational Psychology,* vol. 84, pp. 429-434, 1992.

[13] D.H. Jonassen, *Learning to Solve Problems: An Instructional Design Guide*. San Francisco: Pfeiffer, 2004.

[14] J. Sweller, J.J.G. van Merrienboer & F. Paas, "Cognitive Architecture and Instructional Design," *Educational Psychology Review,* vol. 10, no. 3, pp. 251-296, 1998.

[15] F. Paas, J.E. Tuovinen, H. Tabbers & P.W.M. Van Gerven, "Cognitive Load Measurement as a Means to Advance Cognitive Load Theory," *Educational Psychologist,* vol. 38, no. 1, pp. 63–71, 2003.