A Study of the Effect of Segmentation for Cognitive Load Reduction on Traffic Signs Education in Thailand

Sirilak Borirug
Faculty of Sciences and Liberal Arts, Rajamangala University of Technology Isan, Thailand

Abstract

Road traffic injuries are a major problem in Thailand. One strategy to minimize this problem is to educate Thai Youths on road safety. This paper investigated the effectiveness of a learning instruction designed to use segmenting principles to reduce cognitive load on educating traffic signs for Thai undergraduate students. The study found that segmenting learning instructions supported cognitive load reduction. The relationship between user's satisfaction and the tests was examined. The results showed that the segmenting learning instructions has the higher average values of satisfaction. This resulted from an influence on the higher average score of learning outcomes. Therefore, satisfaction on learning instructions also has an influence on learning outcomes (cognitive load reduction) for learning of traffic signs by Thai undergraduate students.

Keywords: Traffic signs, Cognitive load reduction, Segmenting principle, Multimedia learning

Faculty of Sciences and Liberal Arts, Rajamangala University of Technology Isan
744, Suranarai Road, Muang District, Nakhon RatchasimaProvince, 30000, Thailand
Tel. +66-44-233000 E-mail: Si_bori2002@yahoo.com

Introduction

Road traffic injuries are a major public health challenge that people have to deal every day. WHO (World Health Organization) reported that approximately 1.2 million people are killed in road crashes and as many as 50 million are injured each year (WHO, 2015). Also road accidents have been considered one of the top three public health problems presented by the Ministry of Public Health in Thailand. The report shows that there are over 13,000 deaths and more than million injuries as the results of road accidents each year. This causes losing the economy from road accidents which is from human costs, property damage costs, and general crash costs. From this aspect, the Ministry of Transportation points to road accident is one major problem for this country. There are many factors that cause road-side accidents in Thailand. The Depart of Land and Transport (DLT) has found that one of these factors is due to young drivers who have limited driving skills and knowledge (TARC, 2011). This driving group has been discovered that they have risky driving behaviors and less understanding of the traffic rules. For instant, young drivers, particularly males, often put themselves in potentially hazardous situations such as more likely to drink and drive too fast and also drive too close to the vehicle in front (TARC, 2011 and Tanaboriboom and Satiennam, 2005). Thus, one strategy of this action plan is to educate on road safety for Thai Youths. This plan is to educate on information and actual knowledge on road accidents and traffic rules for driver training and testing.

Cognitive Load Theory (CLT) was developed by John Sweller (1988) designed to give guidelines to help the presentation of information in a manner encouraging learner activities. It is a processing system of learning, memorizing, and problem solving (Sweller, 2008). CLT is an instructional model from the field of cognitive science research. Meaningful learning requires a massive cognitive processing, but the learner's cognitive processing capacity is very limited. At present, multimedia courseware designers have paid increasing attention to this problem. There are close links between cognitive load and learning outcomes, while proper control of cognitive load can effectively improve the academic performance of learners (Artino, 2008). Working memory plays an important role in the storage of information into a long term memory and the acquisition of new skills a long term memory stores the accumulated knowledge. To sum up, if information does not find its way into long term memory, it is lost (Sweller, 1994).

Multimedia learning and segmenting principle

In the field of cognitive science, Mayer (2005) guided us to create more effective computer-based training and multimedia instruction which simply

defines as the presentation of material using words and pictures. Cognitive Theory of Multimedia Learning identifies that multimedia narration and graphical images produce verbal and visual mental representations, which integrate with prior knowledge to construct new knowledge (Mayer and Moreno, 2002). According to Mayer and Moreno (1998) and Mayer (2003), the Cognitive Theory of Multimedia Learning is based on several assumptions. Information technology can utilize multi-sensory channels to convey information from the learning system to the learners, and to assist processing, however, working memory has limited capacity (see Figure 1).

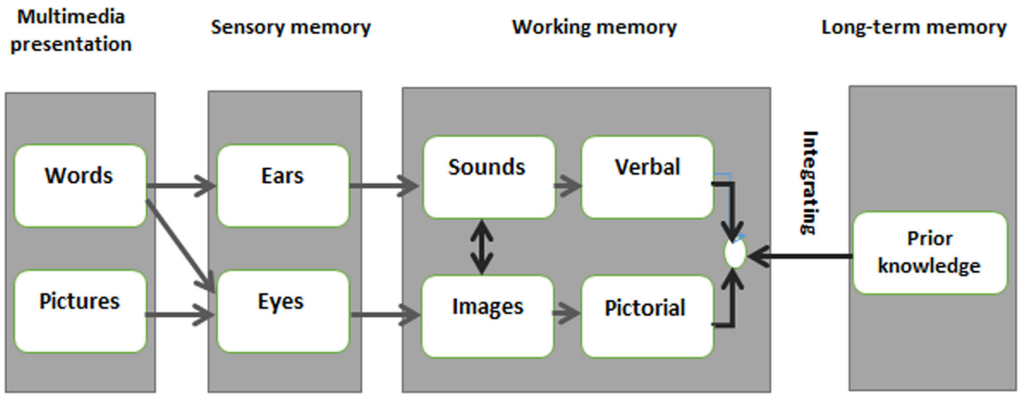


Figure 1 Mayer' model on multimedia learning for cognitive load reduction (source: Mayer, 2005)

This means that presenting too much information in too many channels may cause losing of essential information during learning (Karr-Wisniewski and Lu, 2005). Researchers know that the multiple channels in working memory include auditory and visual channels. The auditory channel handles information that is heard, while the visual channel processes information that is seen (Baddeley, 1992). Text appears to be a unique processing requirements, with words initially captured by the visual channel and then converted to sounds in the auditory channel (Mayer, Heiser and Lonn, 2001). When information is presented using both the visual and auditory channels, working memory can be enabled to handle more information, but there is the risk of cognitive load. Too much information delivered in an ineffective manner can interfere with the brain's ability to successfully integrate information into long term memory (Sweller, 2008). From these aspects, multimedia learning principle can be used for educating traffic rules for drivers, however presenting too much information and various channels may cause cognitive load in learning.

One of the simple principles for reducing cognitive load in learning is segmenting principle. Segmenting is a principle that learner are breaking down the large segments into smaller segments, which are presented one at a time (Mayer, 2012). The segmentation principle states that a multimedia tutorial that provides the learners with pacing control, through use of a Start/Stop button or Continue button, will result in greater learning than a tutorial that plays from beginning to end (Mayer and Chandler, 2001). The rationale for using segmenting is to allow the learner to move their own speed and ingest the information at the speed that works best. Mayer (2005) described that learners understand a multimedia explanation better when it is presented in learner-controlled segments rather than as a continuous presentation and is more likely to be able to process the information more deeply, resulting in enhanced learning.

The purpose of this study is to investigate the multimedia instruction which is a pause segmenting multimedia instruction. This aims to reduce cognitive load. And this study focuses on learners' satisfaction with different learning instructional designs aiming to examine the learners' perception of the multimedia learning instructions. This study will contribute to knowledge and provide a better understanding of the use of new educational technologies for the teaching of traffic signs with an aim to reduce traffic accidents.

Literature Review

There are many studies aimed to solve the problem of cognitive overload. Wang (2010) summarized that makes the learners gain better learning outcomes using multimedia instruction design (Wang, Wu and Zhang, 2010). Multimedia instructions have the capacity to provide powerful presentation to students and learners (Cheon, Chung and Crooks, 2014). For example, Paul Ayres and his team (2009) investigated the effectiveness of instructional animations in teaching human motor skills and static representations. The study showed that students learnt more from the animation mode than the static mode (Khacharem, Spanjers and Zoudji, 2013). However, multimedia learning has associated problems that inhabit the achievement of the best outcome. The research of solving the representation of multi-channel in multimedia environment had been studied in a number of projects. Since the complex information structures in multimedia learning requires more cognitive resources, the segmenting principle has been proposed to reduce cognitive load by providing smaller chunks with pauses (stop/continue) between segments. The effect of Working Memory Capacity (WMC) was examined using the segmentation of multimedia instruction. This study found that there are significant positive effect on participants' recall and application scores, and the use of segmenting principle

allows learners with lower WMC to recall and apply equally to those with higher WMC (Lusk, Evans and Jeffrey, 2009). There was a study shown the findings of valuable implications for effective ways of using pauses between segments in instructional animations. The results showed that active pause with free-recall group outperformed the two passive pause groups on both recall and transfer tests. However, no significant differences in mental effort for the instruction or the tests were found in this study (Cheon, Chung and Crooks, 2014). Another research for reducing cognitive load in learning is to investigate the effects of levels of learner expertise and different forms of segmentation in learning from animated soccer scenes. The study found that an expertise reversal effect for segmentation positively affected learning outcomes of novices but not experts. And novices benefited more from micro-step segmentation than from macro-step segmentation, while experts performed at the same level with both forms of segmentation. This study suggested that adapting instructional animation formats to players with different levels of expertise should be a crucial part of successful training (Khacharem, Apanjers and Zoudji, 2013).

Research questions and Hypotheses

Research Questions (RQ) for this study are followed:

1. Are there any differences in learning outcomes (Cognitive Load Reduction) for learners between traditional instructions (control group) and a pause segmenting multimedia instruction on learning traffic signs?

2. Does satisfaction on learning instructions affect learning outcomes on learning traffic signs?

To achieve the objectives this research, the following null hypotheses of RQ 1 were developed as shown

H1: There is no significant difference between the mean scores from pre-test and post-test of traditional instruction.

H2: There is no significant difference between the mean scores from pre-test and post-test of the pause segmenting multimedia instruction

H3: There is no significant difference between the mean scores from post-test of traditional instruction and the pause segmenting multimedia instruction

According to RQ 2, the satisfaction on learning instructions was investigated. The aim was to examine the learners' perception on the learning instructions with regard to influence on the learning outcomes. This study employed four constructs from Chiu et al.'s model (2005) which were perceived usefulness, perceived ease of use, perceived value, and perceived system quality to measure user satisfaction (Khacharem et al, 2013). The questions for these four constructs were adopted from Chui et al.'s online learning continuance intention model. This could be used as a

criterion on the assessment of the effectiveness of the learning instructional designs. Answers for RQ 2 were therefore based on the following hypothesis:

H4: There will be no significant difference between the mean scores of the learner satisfaction on traditional instruction and the pause segmenting multimedia instruction

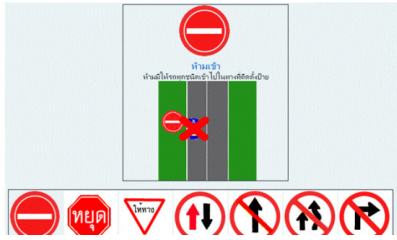
Data Collection Procedures

In this study, there were two groups that consist of one treatment group and one control group (see Table 1). Group A was the control group that was presented with traditional learning instruction provided with only text and images. The treatment group was group B which was presented with the learning instructions based on Multimedia instructions, and was developed including the same contents. The segmenting multimedia instruction (group B) was designed using 2D animation which including two buttons which were "STOP" and "CONTINUE". The participants were required to complete the pre-test questionnaires that contained 30 questions. The lessons contained approximately 20 minutes of instructional materials. Next the participants were requested to finish the post-test and learner satisfaction questionnaires.

The Independent variable of the study is the pause segmenting multimedia instruction. This independent variable is processed in working memory by comparing how various types of loads such as segmenting principle affects selective attention to sensory memory. One of the dependent variable under consideration was an assessment of cognitive load reduction that was measured from scores based on the pretest, posttest results.

The dependent variable was the score from a test obtained in the posttest to measure working memory referred to cognitive load reduction. The other dependent variable is the learner satisfaction on learning instruction. The aim was to examine participant satisfaction in accordance with the learning method provided and reduction of cognitive load in learning traffic signs.

Table 1 Lesson Presentation for treatment group and control group

Control Group (Group A)	Treatment group (Group B)
Text and Pictures	Segmenting Multimedia Instruction
	

Results

The target population of this study was undergraduate students recruited from Nakhon Sawan Rajabpat University in Nakhon Sawan province, Thailand. Participants were between the ages of 18 and 20 and undergraduate students were targeted for the study because the majority of them applied for a new driver's license. SPSS was used to analyze the data and 53 undergraduate students were the participants. All participants were also chosen with similar knowledge background on traffic signs as shown by the mean average score of the pre-test (see Table 2).

According to the RQ 1, the mean scores of the pretest were lower than the posttest of group A and group B. The pair sample T-Test was used to prove the significance of the variable as shown in Table 2. Therefore, the results found that hypotheses 1 and 2 were rejected significantly at the 0.05 level. This describes that both learning instructions affected cognitive road reduction.

In hypothesis 3, the posttest scores between group A and B were analyzed. The results showed that the mean score of the posttest of group B was higher than group A (see Table 2). The hypothesis 3 was rejected with level of significance $\alpha = .05$ (see Table 4). This shows that the segmenting principle affected cognitive load reduction on learning traffic signs in this study.

Table 2 Results from the pair sample T-Test

Group	N	Mean		SD		t	Sig. ed)/2(2-tailed)/2
		Pretest	Posttest	Pretest	Posttest		
A	24	10.46	18.88	2.77	2.63	18.18	0.000
B	29	11.41	23.97	2.10	1.99	39.22	0.000

Level of significance $\alpha = 0.05$ (5% error)

Table 3 reports summary of the mean scores analyzed from five Likert scale of learner satisfactions. There are 57 questions of satisfying evaluation in this study. From hypothesis 4, the p-value of 0.00 shows that there were significant differences between the satisfaction scores of group A and B (see table 4). And the results showed that the mean scores of group B were significantly higher than group A on learner's satisfaction (see table 3).

Table 3 Results from five Likert scale of learner satisfaction

Group	N	Mean	SD
A	24	3.24	0.06
B	29	4.38	0.08

Table 4 Results from the independent sample T-Test

Hypotheses	Levene' s Test for Equality of Variances		t	df	Sig (2-tailed)
	F	Sig			
3	1.73	0.08	-9.60	51	0.000
4	2.08	0.04	-35.77	49.65	0.000

Level of significance $\alpha = 0.05$ (5% error)

This study analyzed the relationship between satisfaction and the posttest of group A which indicated a weak positive linear relationship, r values was 0.0672. And the relationship between satisfaction and the posttest of group B showed a weak negative linear relationship, r values was -0.041.

Conclusion and Discussion

This paper presented an investigation of the effectiveness of a learning instructions designed using segmenting principles in order to support cognitive load reduction on educating traffic signs for undergraduate students in Thailand. The results examined the mean scores of the pretest and posttest. The study found that segmenting learning instructions could support cognitive load reduction. Moreover, the relationship between user satisfaction and the tests was analyzed. As the results, the treatment group of learning showed the higher average values of satisfaction has an influence on the higher average score of learning outcomes. Therefore, satisfaction on learning instructions also has an influence on learning outcomes (cognitive load reduction) for learning of traffic signs by Thai undergraduate students.

The results indicated that the relationships between satisfactions and post-tests of all experiment groups had weak linear correlation.

References

Artino, A. R., Jr. (2008). Cognitive load theory and the role of learner experience: an abbreviated review for educational practitioners. *Association for the Advancement of Computing In Education Journal,16*(4), 425-439.

Baddeley, A. (1992). Working memory. *Science, 255*(5044), 556-559.

Cheon, J., Chung, S., Crooks, S. M., Song, J., & Kim, J. (2014). An investigation of the effects of different types of activities during pauses in a segmented instructional animation. *Educational Technology & Society, 17* (2), 296–306.

Chiu, C., Hsu, M., Sun, S., Lin, T., & Sun, P. (2005). Usability, quality, value and e-learning continuance decisions. *Computers & Education,45*(4), 399-416.

Karr-Wisniewski, P., & Lu, Y. (2010). When more is too much: Operationalizing technology overload and exploring its impact on knowledge worker productivity. *Computers in Human Behavior, 26*(5), 1061-1072.

Khacharem, A., Spanjers, I. A., Zoudji, B., Kalyuga, S., & Ripoll, H. (2013). Using segmentation to support the learning from animated soccer scenes: An effect of prior knowledge. *Psychology of Sport and Exercise, 14*(2), 154-160.

Lusk, D. L., Evans, A. D., Jeffrey, T. R., Palmer, K. R., Wikstrom, C. S., & Doolittle, P. E. (2009). Multimedia learning and individual differences: Mediating the effects of working memory capacity with segmentation. *British Journal of Educational Technology, 40*(4), 636-651.

Mayer, R. E. (2011). Applying the science of learning to multimedia instruction. *Psychology of Learning and Motivation*,77-108.

Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology, 93*(2), 390-397.

Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology, 93*(1), 187-198.

Mayer, R. E., & Moreno, R. (2002). Aids to computer-based multimedia learning. *Learning and Instruction,12*(1), 107-119.

Mayer, R. E. (Ed.). (2005). *The Cambridge handbook of multimedia learning.* New York: University of Cambridge.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*(4), 295-312.

Sweller, J. (2008). Evolutionary bases of human cognitive architecture: implications for computing education (R. Lister, M. Clancy, & M. E. Caspersen, Eds.). In *Proceedings of the Fourth international Workshop on Computing Education Research (ICER 2008)* (pp. 1-2). Sydney: University of Technology Sydney.

Tanaboriboon, Y., & Satiennam, T. (2005). Traffic accidents in Thailand. *IATSS Research, 29*(1), 88-100.

Thailand Accident Research Center. (2011). Progress report no.1: Road safety knowledge development and dissemination. Retrieved November 24, 2016, from http://www.tarc.ait.ac.th/download/eng/ProgressReport1_en.pdf

Wang, B., Wu, F., & Zhang, S. (2010). Reflections on the control of cognitive load in multimedia learning. *2010 Second International Conference on Multimedia and Information Technology.*

World Health Organization. (2018, May 24). Global status report on road safety 2015. Retrieved November 12, 2016, from http://www.who.int/violence_injury_prevention/road_safety_status/2015/en