Effectiveness of Virtual Experiential Learning for Cognitive Load Reduction on Traffic Rules Education

Sirilak Borirug

BA. (Economics), the University of the Thai Chamber of Commerce, Thailand
M. ICT (Informatics), Wollongong University, Australia

THIS THESIS IS PRESENTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY OF MURDOCH UNIVERSITY, AUSTRALIA
YEAR OF SUBMISSION: 2016
Declaration

I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

Sirilak Borirug
Abstract

Road accident is one of the major causes of mortality in many countries. Road traffic education is essential for all drivers in order to improve road safety and minimizes the impacts to the society due to road accidents. Virtual Experiential Learning (VEL) framework is proposed in this study to improve learning by reducing cognitive load in educating undergraduate students on traffic rules in Thailand. The VEL framework is developed based on the Mayer’s model, comprising learning instructions with multimedia presentations including Experiential Learning (EL) techniques, aiming to reduce cognitive overload while focusing on the education of traffic rules. The learning conceptual framework of Virtual Experiential Learning (VEL) combines with learning instructional materials, including multimedia and 3D based video instructions.

This study has been conducted with four different instructional designs, but they presented the same contents. The control group (group A) was based on traditional instructional design comprised text and pictures. Three other experimental groups were: (a) traditional instruction design with EL comprised narration of text and pictures (group B); (b) multimedia instruction design with EL comprised narration of text, pictures, sounds, and 2D animations (group C); and (c) 3D based instruction design with EL comprised of narration of text, pictures, sounds, and 3D videos (group D). The results were compared between pre-test, post-test and final-test scores of four groups of participants.

The results, multimedia instruction delivered with Experiential Learning (EL) and 3D based video instruction delivered with EL has improved learners' knowledge on
traffic rules. It was noted that learners' knowledge was improved using multimedia instructional designs with EL techniques, and it also affected cognitive load reduction in short term memory. The study also found that 3D based video instructions affected cognitive load reduction and it provided the best results in terms of learner's knowledge retention in the long term memory. Finally, the effect of learner satisfaction on cognitive load reduction was examined and it was found that learner satisfactions can affect the learning outcomes.
Acknowledgement

This thesis has taken a while due to many challenges and issues that happened to me during and after my study at Murdoch University. I like to thank my supervisor, Emeritus Professor Dr. Lance Chun Che Fung of the School of Engineering and Information Technology at Murdoch University for his ongoing encouragement, dedication and guidance throughout my study and the development of this thesis. I am most grateful for his counseling and advice, not only the research methodologies but also how to deal with many issues in life. He has been actively interested in my work and he is always available to his students. He has helped me a lot in my professional development and my chosen career. I would not have achieved this far and this thesis would not have been completed without all the supports that I have received from him. Likewise, I’d like to acknowledge and thank my co-supervisor, Associate Professor Dr Kevin Kok Wai Wong, for his assistance in the production of this thesis.

I have to thank Rajamangala University of Technology Isan (RMUTI) for giving me the opportunity to study at Murdoch University, Australia. I shall return and serve the University wholeheartedly. I wish to express my sincere thanks to all participants who took part in this study. They spent their time in using and learning from the VEL framework without them, the completion of this study would not have been possible.

I would like to thank my friends, colleagues and fellow students from the School of Engineering and Information Technology at Murdoch University who have supported me during the stressful process of my research study.
Last but not the least, I would like to thank my family without whose helps, support and encouragement this thesis would have never been completed.
List of Publications

Six Conference papers


Three journal papers


VIII
Summary of Contributions

This study proposed the use of Virtual Experiential Learning (VEL) to improve learning and aimed to reduce cognitive load in learning specifically related to educating young Thai drivers on traffic rules. The main contributions of this thesis that has been published in refereed proceedings are summarized in Table 1 below.

Table 1: Summary of contributions of this thesis

<table>
<thead>
<tr>
<th>Contributions</th>
<th>Description</th>
<th>Paper NO.</th>
</tr>
</thead>
</table>
| Background on Cognitive Load and the approach to reduce Cognitive Load in learning traffic rules | - A proposed framework of VEL framework  
- Selection of Mayer's model on Multimedia to Learning to reduce Cognitive Load  
- Experiential Learning Techniques | J3         |
| Utilization of advanced technology                                           | Using computer based multimedia material such as sound, animation, text, static images, 3D based video | P4        |
| Improving learning strategy for reducing Cognitive Load on educating traffic rules | - Evaluation on performance of each learning instructional design  
- Evaluation on the difference of presenting image styles of each learning instruction  
- Evaluation on designing learning instruction delivered with Experiential Learning  
- Evaluation on the effectiveness of each learning instruction for Cognitive Load Reduction in short term and long term memory  
- Evaluation on the effectiveness on learner satisfaction to reduce cognitive load in learning of each learning instruction | P4, P5, P6, J2, J1 |

IX
# Table of Contents

Declaration ........................................................................................................ II
Abstract ............................................................................................................... III
Acknowledgement ............................................................................................. V
List of Publications............................................................................................. VII
Summary of Contributions ................................................................................ IX
Table of Contents ............................................................................................. X
List of Figures ....................................................................................................... XV
List of Tables ......................................................................................................... XVI
List of Acronyms ................................................................................................ XVII
Chapter 1 .......................................................................................................... 1
  1.1 Introduction ................................................................................................. 1
  1.2 Research Problem ....................................................................................... 4
    1.2.1 Lack of Driver Training ....................................................................... 5
    1.2.2 Cognitive Load Theory and multimedia design................................. 9
  1.2 Purpose of the Study .................................................................................. 11
  1.3 Research Objectives .................................................................................. 12
  1.4 Research Questions .................................................................................. 13
  1.5 Significance of Research ......................................................................... 13
  1.6 Outline of Thesis ....................................................................................... 14
Chapter 2 .......................................................................................................... 18
Cognitive Load Theory and Experiential Learning .......................................... 18
  2.1 Cognitive Load Theory ............................................................................. 18
    2.1.1 Definition of Cognitive Load Theory ................................................ 18
    2.1.2 Types of Cognitive Load ................................................................... 21
  2.2 Cognitive Load Theory and Multimedia Learning .................................... 25
    2.2.1 Multimedia learning and reducing cognitive load ............................. 26
    2.2.2 Multiple channels for information processing ................................... 29
    2.2.3 Mayer’s Instructional Model .............................................................. 30
Appendix D-4: Thai Version of Satisfaction Questionnaire ........................................ 187
Appendix E: Ethic Approval Letter .................................................................................. 192
List of Figures

Figure 1.1: Trends of the number of fatalities due to traffic accidents ........................................ 2
Figure 1.2: The statistics of deaths from road traffic accidents .................................................. 3
Figure 1.3: Statistics on road deaths categorized by age .............................................................. 5
Figure 1.4: Causes of traffic accidents in Thailand 2011-2012 .................................................... 7
Figure 1.5: Thesis construction .................................................................................................... 16
Figure 2.1: Information Processing Model based on Mayer (2005) .............................................. 31
Figure 2.2: EL’s model of Dewey’s model (1980) ........................................................................ 35
Figure 2.3: The four modes of Kolb’s Experiential Learning Cycle ............................................ 36
Figure 3.1: Conceptual VEL Framework ....................................................................................... 39
Figure 4.1: Research Design ........................................................................................................ 52
Figure 4.2: Research Phases ......................................................................................................... 53
Figure 4.3: Two-group pre-test-post-test quasi-experimental designs ........................................ 56
Figure 5.1: The propose of VEL framework for Cognitive Load Reductions .............................. 80
Figure 5.2: An overview of learning system based on the VEL framework ................................. 83
Figure 5.3: An example screen shot of the lesson learned for group A ....................................... 85
Figure 5.4: An example screen shot of the lesson learned for group B ....................................... 85
Figure 5.5: An example screen shot of the lesson learned for group C ....................................... 86
Figure 5.6: An example screen shot of the lesson learned for group D ....................................... 86
Figure 5.7: An example screen shot of the 3D video of group D .................................................. 87
Figure 5.8: An example screen shot of practice section of group B, and C ................................. 88
Figure 5.9: An example screen shot of practice section of group D ............................................ 89
Figure 5.10: An example screen shot of the tests ........................................................................ 90
Figure 6.1: Summary of research results ...................................................................................... 103
Figure A.1: System Flow Chart ................................................................................................... 153
Figure A.2: Data flow diagram ..................................................................................................... 154
Figure B.1: The interface of lesson learned of group A (control group) ....................................... 155
Figure B.2: The interface of lesson learned of group B ............................................................... 156
Figure B.3: The interface of lesson learned of group C ............................................................... 157
Figure B.4: The interface of lesson learned of group D ............................................................... 158
Figure B.5: The interface of examples of 3D videos ................................................................. 159
Figure B.6: The interface of the test questions ............................................................................. 160
Figure B.7: The interface of the practices ..................................................................................... 161
List of Tables

Table 1: Summary of contributions of this thesis ................................................................. IX
Table 3.1: The Hypotheses for determining the effectiveness of learning instructions delivery with Experiential Learning .................................................................................. 43
Table 3.2: Hypotheses for determining the effectiveness of learning instructions on Cognitive Load Reduction ........................................................................................................ 46
Table 3.3: Hypotheses for determining the effect of satisfaction to learning instructions ................................................................................................................................. 50
Table 4.1: Lesson Presentation for the five experimental groups and a control group .. 59
Table 4.2: Analysis instruments for validity testing ................................................................. 61
Table 4.3: Analysis instruments for reliability testing ............................................................... 63
Table 4.4: Guidelines for interpreting item discrimination index (Hopkins, 1998) .......... 74
Table 4.5: Rating scale of a Likert Scale .................................................................................. 75
Table 5.1: Example traffic signs using Thai language ............................................................. 82
Table 6.1: Validity testing for evaluation learning instructions ............................................... 94
Table 6.2: Reliability testing for evaluation learning instructions ........................................... 97
Table 6.3: Classification of the p-value .................................................................................... 98
Table 6.4: Cronbach’s alpha with 57 items .............................................................................. 99
Table 6.5: Information about the participants ......................................................................... 100
Table 6.6: Pretest comparing for knowledge background ....................................................... 101
Table 6.7: The results of the Pair Sample T-Test for hypotheses 1 to 4 ......................... 104
Table 6.8: The results of the Pair Sample T-Test for hypotheses 5 to 8 ......................... 106
Table 6.9: Summary of the mean score of the tests ................................................................. 107
Table 6.10: Results of the Independent Sample T-Test for hypotheses 9 to 14 ........... 108
Table 6.11: Results of the Pair Sample T-Test for hypotheses 15 to 18 ......................... 111
Table 6.12: Results of the Independent Sample T-Test for hypotheses 19 to 24 ....... 113
Table 6.13: Mean score of learner satisfactions ..................................................................... 118
Table 6.14: Learner satisfaction results .................................................................................. 118
Table 6.15: Correlation coefficient interpretation guidelines .................................................. 122
Table 6.16: Results of Pearson’s correlation coefficients ......................................................... 122
## List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLT</td>
<td>Cognitive Load Theory</td>
</tr>
<tr>
<td>EL</td>
<td>Experiential Learning</td>
</tr>
<tr>
<td>VEL</td>
<td>Virtual Experiential Learning</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>DLT</td>
<td>Division of Land and Transport</td>
</tr>
<tr>
<td>TARC</td>
<td>Thailand Accident Research Centre</td>
</tr>
<tr>
<td>OTP</td>
<td>Office of Transport and Traffic Policy and Planning</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>IS</td>
<td>Information System</td>
</tr>
<tr>
<td>RSC</td>
<td>Road Safety Culture</td>
</tr>
<tr>
<td>RSDC</td>
<td>Road Safety Direction Centre</td>
</tr>
<tr>
<td>NSO</td>
<td>National Statistical Office</td>
</tr>
<tr>
<td>IOC</td>
<td>Item-Objective Congruence IOC</td>
</tr>
</tbody>
</table>
Chapter 1

Introduction and Background of Research

1.1 Introduction

This research aimed to reduce cognitive load by using multimedia learning as the instructional design on educating undergraduate students in traffic rules in Thailand. Motor vehicles have long been utilized extensively in modern societies as a convenient means of transportation. However, the community also pays a heavy price for such convenience. Motor vehicle crashes and traffic related accidents have since become a leading cause of death and disability worldwide, causing much agony and pain to many families and crippling cost to the community. Road traffic systems are one of the most complex and dangerous environments in which many people have to deal with every day. Nowadays, road traffic injuries are one of the leading causes of death worldwide. It is likewise a major public health challenge that requires substantial efforts for effective prevention [Peden et al. 2004]. Among the population; children, pedestrians, cyclists and elderlies are vulnerable road users. More than 1.2 million people die on the road, worldwide, every day and many are injured or disabled every year [WHO 2015]. Research by Penden et al. stated in 2004 that these figures will rise by 65% over the next 20 year [Peden, Scurfield, Sleet, Mohan, Hyder, Jarawan and Mathers 2004]. When comparing the number of fatalities due to traffic accidents, the number of deaths is often given per 100,000 inhabitants per year (deaths/100,000/year). WHO and other organizations categorize countries into low income and high income countries, with the
low income countries having almost invariably more deaths due to traffic accidents than the high income countries. While low and middle income countries are facing more serious road accidents, the trend in high income countries is in the opposite direction. A sharp difference in fatality rates between high and low income countries is shown in Figure 1.1. Over the years, fatality rates in high income countries have been declining, while in the low- and middle-income countries, they are moving in an upward trend. This may be due to newer vehicles with better safety design are used in the high income countries, while the average age of the motor vehicles in the low and middle income countries is expected to be higher.

Figure 1.1: Trends of the number of fatalities due to traffic accidents

As seen in the graph above, most ‘poor’ or developing Asian countries are suffering from higher fatalities rates in comparison with the U.S.A., European countries and Japan, according to 2013 data from WHO. In the graph, Thailand shows the highest number of deaths/100,000/year among the Asian countries.
In Thailand, road accidents are considered as one of the top three public health problems in the country according to information released by the Ministry of Public Health [DLT 2013]. For many years, Thailand has faced the loss of many lives due to road casualties, in comparison to other causes. Over the years, the number of Thai people killed on the road has an average figure of about 12,000 per year, or about 2 persons being killed per hour [DLT 2013]. Every day, road accidents have not caused only death and disability among the Thai community, but also substantial damages to the country’s economy. It was estimated in 2005 that the economy losses due to road accidents in Thailand are over 100,000 million Baht or approximately 2,500 million USD per year [Tanaboriboom and Satiennam 2005]. This also means over 12 million Baht per hour or about 3.4 % of the country’s GNP [DLT 2013]. The economy losses from road accidents are mainly due to medical costs, property damages, and general crash costs.

![Trend in Reported Road Traffic Deaths](image)

**Figure 1.2: The statistics of deaths from road traffic accidents [RSC 2015]**
1.2 Research Problem

Statistics have shown road traffic injuries is the leading cause of death among young people aged 15-29 years [WHO 2015]. Each year nearly 300,000 people under 29 die on the world’s roads, or an average of more than a thousand deaths a day [WHO 2015]. In Figure 1.3, statistics and related documents have pointed out the fact that those age between 15 to 24 years old have the highest fatality rate between 2001 and 2011 in Thailand [DLT 2013]. The Thailand Accident Research Center (TARC) has investigated and reported many factors that caused road-side accidents in Thailand. One of these factors is due to young drivers who have limited driving skills, experience and knowledge [TARC 2008]. It has been found that this group of drivers has less understanding of the traffic rules and some of them exhibit risky driving behaviors. For example, young drivers, particularly males, often put themselves in potentially hazardous situations such as involved with excessive drinking and speeding, they also drive too close to the vehicle in front [Tanaboriboom and Satiennam 2005; TARC 2008]. Thus, one strategy of this action plan is to educate Thai youths on road safety. The plan is to educate them on information, knowledge and facts about road accidents and traffic rules in addition to driver training and testing.
1.2.1 Lack of Driver Training

A reduction in the number of crashes or injuries resulting from crashes might be considered as an outcome for measuring the effectiveness of a road safety education program [Raftery and Wundersitz 2011]. Driver training typically refers to a process involving the teaching of practical skills necessary to control or operate a vehicle. This includes aspects such as changing direction, accelerating, maintaining speed, and braking. On the other hand, driver education is a much broader term, which incorporates training, and is used in reference to additional educational practices. It focuses on knowledge that includes the awareness of the road laws and driving behavioral components, and it also incorporates training. There has always been considerable expectation from formal education and training. Indeed, such programs are generally accepted as an efficient and effective means of learning to drive and for
preparing to take the road test, which sets the minimum driving standards as required by the relevant authority.

Unfortunately, most drivers in Thailand have not participated in in-depth driver education courses and few drivers in Thailand have any formal training in the working of their cars or safe defensive driving strategies. This is a real lack of self-awareness coupled with over-confidence that creates one of the greatest risks. Inexperienced drivers, especially young ones, have extremely high crash rates. A major reason that young drivers are over represented in road crashes is because they lack in the necessary driving skills and they don’t have the capabilities to handle unexpected situations [Tanaboriboom and Satiennam 2005]. The fact that most drivers have had no formal training in defensive driving also leads to a great number of accidents. Driver training is therefore an intuitively logical solution to a serious problem that is generally attributed to inexperience and lack of skills [Raftery and Wundersitz 2011].

In addition to traffic accident prevention, it is important to understand the causes of accidents, their characteristics and locations where accidents frequently occur. Identifying the risk factors that contribute to road traffic crashes is important in establishing interventions that can reduce the risks associated with those factors. Road traffic crashes result from a combination of factors related to the components such as conditions of the roads, the surrounding environment, working of the vehicles, road users, and the way all these components interact. As shown in Figure 1.4, driver impairment is an important component of road traffic accidents. Driving at excessive speeds, while under the influence of alcohol or drugs is a major cause of accidents according to the statistics. In particular, it can be established that many
accidents are caused by drunk driving [Ditsuwan et al. 2011]. Other research also pointed out that impairment by alcohol is an important factor influencing the risk of a road crash while the speed of motor vehicles is also at the core of the road traffic injury problem [Kanitpong et al. 2013]. The physical layout of the road and its surroundings can either encourage or discourage speeding. Crash risk increases as speed increases, especially at road junctions and while overtaking. It is common that road users underestimate the speed and overestimate the distance of an approaching vehicle.

![Figure 1.4: Causes of traffic accidents in Thailand 2011-2012][NSO 2013]

Given sufficient precautions, road traffic crashes may be preventable. The government must take action including raising the awareness of, and the enforcement of laws concerning speed limits, alcohol impairment, using of seat-belts, child restraints,
and crash helmets while riding motor bikes. These are also causal aspects of problem behaviors in general which include risk awareness, resilience, and problem solving.

One strategy of the action plan is to educate drivers on road safety. The plan is to reinforce information and knowledge on road accidents and traffic rules for driver training and testing. Organizations with an interest in road safety such as emergency services, motoring organizations, governments, health professionals, and community groups are continually looking for new and innovative ways to increase drivers’ road safety knowledge, and to promote safe and responsible road use. These are based on established principles of best practices for both education and behavior change [Tanaboriboom and Satiennam 2005; TARC 2008]. Moreover, a number of road safety programs have sought to improve road safety through the provision of training that is intended to improve young drivers’ ability to control a motor vehicle. Other more successful programs teaching similar skills have involved lengthier training with multiple sessions of practices on the road [Vasconcellos 2005].

Finding method for developing effective learning instruction is one of the most important strategies in the field of learning. In particular, Cognitive Load Theory (CLT) is a theory that achieves effective content-development techniques in the fields of educational engineering and educational psychology [Feinberg and Murphy 2000]. CLT describes learning in terms of an information processing system made up of working (or short term) memory and long term memory which stores knowledge and skills on a permanent basis [Sweller 1994]. Traffic rules are such information that must be stored in the long term memory in order to help drivers to gain more knowledge and capacity on driving. The next section describes the Cognitive Load Theory (CLT) as regard to
multimedia teaching design which is believed that it can provide better results on education in traffic rules for drivers.

1.2.2 Cognitive Load Theory and multimedia design

Recently, there has been an increased focus on the effectiveness and efficiency of instructional design strategies in education and training. In the field of instructional technology, information technology plays an important role to increase the effectiveness and efficiency of various instructional design strategies [Mayer and Mereno 2003]. The benefits of information technology such as the provision of various forms of presentations are the main factor being used to design the learning instructions to solve the problem of cognitive overload [Aidi 2009; Mayer and Mereno 2003]. With the development of information technology and popularization of computer applications, traditional teaching model has changed to multimedia teaching model. Multimedia teaching model is computer-centered using texts, images, audios, videos, animations and other information carriers in teaching, and the model creates a favorable learning environment for learners [Mayer 2002]. Multimedia teaching design is therefore utilized for educating young driver on road traffic rules in this study. Multimedia learning can be identified in a number of ways. This has been defined that “study depends on multimedia presentation is called multimedia learning” [Mayer 2005]. In multimedia learning there exist some problems which need to be dealt with, for example, how to optimize the design of multimedia teaching materials, so as to help learners achieve the best learning outcomes. In multimedia teaching, nevertheless, instructors often face the challenge of excessive cognitive load [Liying 2011; Mayer et al. 2001] according to the Cognitive Load Theory (CLT).
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 Jr 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]. Further details of CLT will be discussed in Chapter Two.

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. This means that presenting too much information in too many channels may cause losing of essential information during learning [Karr-Wisniewski and Lu 2010]. 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].
Moreover, when an excessive amount of information is presented in a short period of time, this causes a learner to spend too much mental energy to handle such information [Mayer, Heiser and Lonn 2001; Mayer and Mereno 2003]. This may result in the learner ignoring the content as the computer may have presented too much unnecessary or even distracting information. In addition, while a learner may be provided with a great deal of video information, this may cause cognitive overload in the pictorial channel [Aidi 2009]. In instructional designs, while it can be designed with a multitude of choices, inputs and navigational paths through the information landscapes, this may cause learners to get confused and subsequently will miss the target information [Hedberg et al. 1993].

1.2 Purpose of the Study

In Thailand, any person of 18 years and above is eligible to apply for a driving license for private cars and the age for motor-cycle riders is 15 years old. An applicant has to pass both a theory test on the traffic rules and a practical test on the road. There is no probation period in Thailand for new drivers and learners are not allowed to be on the road without a licensed instructor. Moreover, all drivers need to renew their license every five years and they need to undergo an hour of retraining. There is however no requirement for retest before renewal of the license. For the majority undergraduate students, most likely they will apply for the driving license as soon as they reach the legal age. From these aspects, this study is aimed to improve road safety for Thai undergraduate students as they have limited driving skills and knowledge [WHO 2015]. This driving group has been found that they have limited understanding of the traffic rules and risky driving behaviors [Tanaboriboom and Satiennam 2005; WHO 2015].
This is clearly a need to improve road safety education utilizing more effective approaches.

In Thailand, computers with Internet access are now readily available, in particular among all undergraduate students. Therefore, this study proposes the use of Virtual Experiential Learning (VEL) to improve learning and aims to reduce cognitive load in learning specifically related to educating Thai undergraduate students on traffic rules. VEL is virtual learning which combines Experiential Learning (EL) techniques in a framework comprises of traditional learning instructions, multimedia instructions, and 3D based video instructions. Experiential learning is the process of making meaning from direct experience, that is, the knowledge and skill obtained from participation or engagement in practical activities [Klob 1984; Kolb et al. 2000]. Thus, the use of VEL is aimed to assist learners to retrieve information in order to rethink or reorganize the working memory as the retrieval process plays a major role in helping to recall information thereby increases efficiency of the storage processes [Cao and Liu 2009]. Moreover, learners will be provided with lessons and practices through the Internet such that learners may access to the learning system anywhere and anytime, provided they have access to the Internet.

1.3 Research Objectives

This study focuses on how to reduce a learner’s cognitive load in the context of educating young Thai drivers on traffic rules. The main purpose of this thesis is to investigate the efficiency of a VEL framework which aims to reduce cognitive load on educating undergraduate students in traffic rules in Thailand. The study investigated the effectiveness of EL contributing towards cognitive load reduction. This study also
researched into the difference in the learning outcomes and learners’ satisfaction based on different learning instructional designs in the context of educating Thai undergraduate students on traffic rules.

1.4 Research Questions

The research questions addressed in this study are:

1) Does Experiential Learning affect cognitive load reduction on learning of traffic rules by Thai undergraduate students?

2) Are there any differences in learning outcomes (cognitive load reduction) for learners between (a) traditional learning instructions, (b) multimedia instructions, and, (c) 3D based video instructions on educating Thai undergraduate students on traffic rules?

3) Does satisfaction on learning instructions affect learning outcomes due to cognitive load reduction on learning of traffic rules by Thai undergraduate students?

1.5 Significance of Research

This study focused on the reduction of cognitive load on educating Thai youths on traffic rules in Thailand. The study contributed to knowledge and provided a better understanding of the use of new educational technologies for the teaching of traffic rules to Thai undergraduate students with an aim to reduce traffic accidents. Previous research reports have shown that information technology may help to reduce cognitive overload [Austin 2009; Cao et al. 2009]. Therefore, the result of this research has provided a better understanding of the effectiveness and efficiency of various
instructional design strategies and the use of information technology associated with the mental process of learning. A better understanding on applying multimedia instructions and 3D videos to facilitate learning on the reduction of cognitive load has been achieved in this research. Moreover, Experiential Learning Theory was applied to support cognitive load reduction. This study contributed towards a better understanding of how to improve the education of traffic rules using experiential learning environments.

1.6 Outline of Thesis

This thesis is presented in seven chapters. These are:

Chapter One describes the research background including the research problems and their context with respect to the needs for education on traffic rules in Thailand. The research questions, hypotheses, and research objectives are provided. This thesis initially explores the VEL framework for educational purposes on traffic rules and the overall research significance addressed by this research.

Chapter Two provides background on cognitive load theory and different types of cognitive load theory. Moreover, this chapter describes the meaning of EL and their application in instructional settings and how EL could support the constructivist learning framework.

Chapter Three describes the research framework and hypotheses development for measuring the VEL framework on educating traffic rules. The hypotheses are discussed for evaluating the learning outcomes in order to measure different learning
instructional designs which caused effects on cognitive load reduction in learning for this study.

Chapter Four describes the methodology adopted for this study. This chapter covers the following aspects: the methods used in the study, how the materials were prepared for the study, the research protocol, how measurements were made, how the calculations were performed, and the statistical tests used for data analysis. This chapter also includes an extensive discussion of research design, research methodology, and research evaluation. Firstly, the research design is developed which consists of multiple phases of the research framework created to seek answers to the research questions. Secondly, the detailed study of data collection methods is discussed. Finally, the evaluation results are discussed and used to assess the effectiveness of the proposed system.

Chapter Five presents the design and development of the VEL framework. The design of the purposed system including the features of the learning process is described in this chapter.

Chapter Six presents the research results and findings of the study in terms of three main sections. In the first section, the results from the test of validity and reliability on instruments are discussed. In the subsequent section, the results from the tests of four participant groups having learnt from the learning instructions are elaborated in more details. In the third section, the results from the learner’ satisfaction on the learning instructions are presented.

Chapter Seven discusses the results of all the questionnaires and data analysis. In this thesis, all results are used to verify their support for the research hypotheses and to provide answers to the three research questions. Moreover, this final chapter
presents the summary of research findings and discussions on the VEL framework and the cognitive load reduction system. Finally, this chapter provides a summary of completed work in this thesis, limitation and directions for future work. The summary of details on thesis chapters is summarized in Figure 1.5.

Figure 1.5: Thesis construction
Chapter 2

Cognitive Load Theory and Experiential Learning

The chapter reviews what have been established in the literature about Cognitive Load Theory, Multimedia Learning and their relationships. The theoretical frameworks including EL techniques that guided the design of this study and the interpretation of the findings are also covered in this chapter.

2.1 Cognitive Load Theory

2.1.1 Definition of Cognitive Load Theory

Cognitive Load Theory (CLT) has become one of the most influential theories in instructional psychology with applications in various areas of education [Ando and Ueno 2008]. In recent years, there has been an increased focus on the role of education and training, and on the effectiveness and efficiency of many instructional design strategies. Some of the most important breakthroughs in this issue have come from the discipline of Cognitive Science, which deals with the mental processes of learning, memory and problem solving [Pass et al. 2003]. CLT is an instructional theory rooted in the discipline that describes learning structures in terms of information processing systems. It involves long term memory, which effectively stores all of the knowledge and skills on a permanent basis and working memory. Information may only be stored in long term memory after first being attended to, and processed by, working memory. Working memory, however, is extremely limited in both capacity and duration. These limitations impede learning under certain conditions. The fundamental assumption of this theory is
that instructional methods to be effective. Instructional designers need to take human cognitive architecture into account. It also emphasizes the necessity for instructional techniques to be designed in alignment with the basic operational principles of the human cognitive system [Pass, Renkl and Sweller 2003; Sweller 1994; Sweller 2011; Sweller et al. 2008]. Based on the attempt to understand human cognitive architecture, CLT identifies many traditional instructional techniques do not consider the limitations of human cognitive capacity and this leads to overload in a learner's working memory [Schnotz and Kürschner 2007]. CLT establishes the assumption that working memory architecture and its processing limitations should be considered when designing instructions [Paas et al. 2003]. In other words, it was stated that “overloading learners' working memory makes learning difficult. So to facilitate learning instruction should minimize overloading learners' cognitive system”. [Ayres and Paas 2007]. The fundamental principle of cognitive load theory is that the quality of instructional design will be raised if greater consideration is given to the role and limitations, of working memory. Since its conception in the early 1980's, cognitive load theory has been used to develop several instructional strategies which have been demonstrated empirically to be superior to other instructional strategies used conventionally.

- **The limitations of working memory**

  Humans are only conscious of the information currently being held and processed in working memory and are essentially oblivious to the enormous amount of information stored in long term memory [Sweller et al. 1998]. However, working memory is severely limited in both capacity and duration when handling new information. Working memory can only hold about seven (plus or minus two) items, or chunks of
information, at a time [Baddeley et al. 1975; Miller 1956]. Additionally, when processing information (i.e., organizing, contrasting, and comparing), rather than just storing it, humans are probably only able to manage two or three items of information simultaneously, depending on the type of processing required [Kirschner et al. 2010]. Finally, new information held in working memory if not rehearsed, is lost within about 15 to 30 seconds [Driscoll and Driscoll 2005]. This forms one of the fundamental concepts behind CLT.

- Long term memory

Information held in long term memory is organized and stored in the form of domain-specific knowledge structures known as Schemas [Van Merriënboer and Ayres 2005]. Schemas categorize elements of information according to how they will be used, thereby facilitating schema accessibility later when they are needed for related tasks [Sweller, Van Merrienboer and Paas 1998]. Thus, from the CLT perspective, “human expertise comes from knowledge stored in these schemata, not from an ability to engage in reasoning with many elements that have not been organized in long-term memory” [Van Merriënboer and Ayres 2005]. Sweller (2008) proposed that the relationship between working memory and schemas stored in long term memory may be even more important than the processing limitations of working memory. This is because schemas do more than just organize and store information; they also effectively augment working memory capacity [Sweller, Ayres and Kalyuga 2008].
2.1.2 Types of Cognitive Load

There are three types of cognitive load which are intrinsic, extraneous, and germane cognitive load. The total cognitive load is identified by the sum total of these three sources of load. Throughout this work, the term 'mental effort' is used as an index of cognitive load. Some forms of cognitive load are useful, while others waste cognitive and mental resources. Since the total mental capacity is limited, learners need to balance the three forms of cognitive load to maximize learning efficiency. In particular, an effective instruction should consider minimizing the unproductive intrinsic and extraneous cognitive load while stimulating the desirable germane cognitive load [Sweller, Van Merriënboer and Paas 1998]. These three types of cognitive load are described as follow.

- Intrinsic Cognitive Load

The first type of cognitive load is intrinsic cognitive load. This load refers to the complexity of the learning material that a learner intends to learn mentally. The intrinsic cognitive load is intrinsic or inherent in the nature of the material or task being taught [Kirschner, Ayres and Chandler 2010; Sweller, Ayres and Kalyuga 2008]. It is dependent on the intrinsic nature (difficulty level) of the learning material and also on the learner’s amount of prior knowledge. Prior knowledge is included in this definition because the size of meaningful information “chunks” that a learner can handle without taxing his or her limited working memory capacity is dependent upon it. A learning task that might be complex for a beginner may, on the other hand, be simple for an expert. In particular, intrinsic cognitive load is determined by the extent to which various elements interact in order to successfully perform a task. An element is the information
that can be processed by a particular learner as a single unit in working memory [Paas, Tuovinen, Tabbers and Van Gerven 2003]. Therefore, element interactivity is the main generator of intrinsic cognitive load [Sweller 1994]. In addition, this type of load depends on the number of elements of learned material that must be processed simultaneously in working memory [Van Merriënboer and Ayres 2005]. It is believed that high element interactivity causes high intrinsic cognitive load. It is also assumed that this type of cognitive load is not controlled by instructional techniques. However recently, the possibility of reducing intrinsic cognitive load by manipulating the material element interactivity and the subject-task interaction has been suggested [Pass, Renkl and Sweller 2003].

A task is an obstacle in the learning process because many elements have to be incorporated simultaneously, not because of the number of elements that a task contains [Pollock et al. 2002]. Therefore, when a task is low in element interactivity, it is easy to find out. This is shown that containing elements that can be learnt in isolation rather than simultaneously. This results in a minimal working memory load effectively. This is explained by the fact that the task can be learnt without holding more than a few elements in the learners' working memory at once.

In contrast, when a task is high in element interactivity, it is difficult to learn as many elements interact at once. This results in high working memory load [Ayres 2006; Pollock, Chandler and Sweller 2002; Sweller 1994]. Also, Van Merrienboer, Kester and Paas (2006) suggested that element interactivity in a task depends on a learner's expertise. This is because numerous elements for a low expertise of learner may be chunked into one or a few elements for a high expertise of learner. Therefore, the
expertise of the learner plays an important role in determining the intrinsic cognitive load or complexity of the material. Subsequently, Sweller and his colleagues modified the theory to claim that learners and instructors can reduce intrinsic cognitive load by reducing the number of interacting elements.

- **Extraneous Cognitive Load**

  The *extraneous cognitive load* is the second type of cognitive load. Extraneous load is imposed by information and activities that do not directly contribute to learning [Sweller 2011]. The extraneous load refers to mental activities during learning that do not contribute directly to learning. Extraneous load can also be varied based on the manner in which information is presented and the activities required of learners [Pass, Renkl and Sweller 2003; Van Merriënboer and Ayres 2005]. This is referred to disadvantageous, unnecessary, or extraneous cognitive load [Pass, Renkl and Sweller 2003; Sweller, Van Merrienboer and Paas 1998]. In particular, extraneous cognitive load results from inadequately designed instruction. Therefore, extraneous cognitive load is assumed to be controlled by instructional methods. This is because this type of cognitive load interferes with learning. To reduce this kind of cognitive load by designing suitable instructional methods has been a primary purpose of CLT [Van Merriënboer and Ayres 2005]. When dealing with material which is low in element interactivity, reducing extraneous cognitive load may not be necessary. This is because the total cognitive load may not exceed working memory capacity. In opposite, when teaching in an area with high elements interactivity, reducing extraneous cognitive load is assumed to be critical [Sweller 1994]. Cognitive load theory suggests various techniques to manipulate extraneous cognitive load such as presenting materials using
dual mode instruction and an emphasis on using worked examples instead of conventional problems [Mayer and Moreno 1998].

- **Germane Cognitive Load**

  The third type of cognitive load according to CTL is *germane load*. The germane load refers to the demands placed on the working memory that is imposed by mental activities that contribute directly to learning. In the case of worked examples, *self-explanatory activities* would be regarded as a germane load. Self-explanations refer to a learner's effort in gaining a better understanding of a solution rationale, such as trying to find the domain principle underlying a certain solution step. This type of cognitive load was discussed by Sweller, van Merrienboer and Paas (1998). It is defined that germane load is directly contributing to learning, that is in the learner's construction of cognitive structures and processes that improve performance. [Van Merriënboer and Ayres 2005]. Germane cognitive load is the mental processing that is imposed by instructional design that positively contributes to achieving better learning outcome. The basic assumption of generating germane cognitive load is that, when an instructional design or learnt information does not occupy the whole working memory capacity because of a low intrinsic and extraneous cognitive load. Increasing germane load may enhance learning process. That happens through engaging learners in conscious cognitive processing that is directly relevant to schema construction [Kirschner, Ayres and Chandler 2010].

  Kirschner also emphasized that employing germane load should be employed within working memory limits. Furthermore, there are some strategies that can be used to influence germane cognitive load. Using worked examples for novice learners and
increasing worked example variability can promote students’ self-explanations for the rationale behind worked-out solution steps, which may induce a germane cognitive load [Pass, Renkl and Sweller 2003].

2.2 Cognitive Load Theory and Multimedia Learning

In the field of instructional technology, Multimedia Learning plays an important role to increase the effectiveness and efficiency of various instructional design strategies [Mayer and Mereno 2003]. The benefits of Multimedia Learning such as the providence of various forms of presentations are the main factor being used to design the learning instruction to solve problem of cognitive overload [Aidi 2009; Mayer and Mereno 2003]. On the other hand, Multimedia Learning can utilize multi-sensory channels for conveying information from the learning system to the learners, and to assist processing. However, working memory has limited capacity, presenting too much information in too many channels may cause losing of essential information during learning [Karr-Wisniewski and Lu 2010]. One of the main problems emerges when there is an excessive amount of information presented in a short period of time and this can cause a learner to spend too much mental energy to handle such information [Mayer, Heiser and Lonn 2001; Mayer and Mereno 2003]. This may result in the learner ignoring the process of the content as the computer may present too much unnecessary or even distracting information from its large data storage. In addition, while a learner may be provided with a great deal of video information, but this may cause cognitive overload in the pictorial channel [Aidi 2009]. In instructional design, while it can be designed with a multitude of choices, inputs and navigational paths through the information landscapes
Nowadays, multimedia offers exciting possibilities for meeting the needs of learners. Multimedia learning can be defined as the delivery of instructional content using multiple modes. These multimedia modes are visual and auditory information that a learner uses to construct knowledge. This increased reliance on technology combined with brain processing, offers vast potential for instructional designs. Many researchers have shown that the brain processes information using two channels which are visual and auditory. When information is presented using both channels, the brain can accommodate more new information. By taking advantage of this multimodal processing capability and technology based tools, this can dramatically enhance learner to learn through multimedia instruction. To understand how multimedia can help students learn, it is important to understand the basics of how the brain processes information. The cognitive theory of multimedia learning represents an attempt to help achieving compatible with how people learn by describing how people learn from words and pictures. This goal is based on consistent empirical research evidence and on consensus principles in cognitive science. The design of multimedia instructional messages is an important strategy. In short, the design of multimedia instructional messages should be thoughtful about how people process information.

2.2.1 Multimedia learning and reducing cognitive load

The cognitive theory of multimedia learning applies to the multi-sensory components that are employed to facilitate learning in multimedia environments. The theory asserts higher-order learning is achieved when learners are given the
opportunity to formulate mental connections between images and verbal representations [Mayer 2005]. The two compatible channels work concurrently to facilitate mental representations. The information is organized into two separate channels of working memory when learners actively select the relevant external resources (Brünken, Plass & Leutner, 2003). “Words and sentences are usually processed and encoded in the verbal system, whereas pictures are processed and encoded both in the imagery system and in the verbal system” (Schnotz & Bannert, 2003, p.142). In other words, in the visual system the information is coded twice. One of the objectives of instructional learning design is to find ways to manage cognitive load so it will benefit the individual learner (Brünken et al., 2003).

To reduce cognitive load, there are various guidelines proposed by researchers and learning developers on how to design learning environments. These guidelines suggest that the designs should aim to reduce extraneous load, to foster germane load, and to manage intrinsic load. The next paragraph will elaborate on the identification of these guidelines.

- **Reducing extraneous cognitive load**

  To reduce extraneous cognitive load is mainly to reduce the processing of information by the learner such as reduction of redundant information as possible to achieve learning objectives presented directly to the content [Wang et al. 2010]. The use of graphics in multimedia instruction to learning is an effective way to reduce the extraneous cognitive load. This can be illustrated with the use of charts which include the spatial relationships and spatial processing tasks of learning. Compared with what can only be processed according to the order of the sentences, all the visual elements
of a chart can be seen at the same time. This reduces the number of spatial elements including the coordination of tasks in visual search. Furthermore, the same information resources using a different working memory channel will lead to redundancy effect. Therefore, the elimination of redundant material is an effective way to reduce the extraneous cognitive load. Redundancy may occur in the same information being presented in different ways and this has a negative effect. Moreover, presenting information at the appropriate time is also another effective way to reduce extraneous cognitive load. The learners need the exact information, while the information should include supportive and prerequisite information [Wang, Wu and Zhang 2010]. Supportive information is best presented before practicing the task, and the prerequisite information should be presented in the learning process. These effective ways can effectively reduce the extraneous cognitive load.

- **Increasing germane cognitive load**

  Learning instructions should present multiple examples, incomplete examples, instructional support, and the structure of the examples [Van Merriënboer and Ayres 2005]. All these means to increase germane cognitive load aim at fostering self-explanations. Presenting several examples is to allow learners to compare between them. This means that learners have the opportunity to determine the differences between examples of one category for understanding aspects of the examples.

- **Reducing intrinsic Cognitive Load**

  Complicated interaction among elements can cause intrinsic cognitive load. Thus, the main method of reducing the intrinsic cognitive load is to reduce such
interactions among the elements. To simplify the overall task, an example is when learners start to learn, a simplified version of the task is taught first, and then followed by sub-tasks, and gradually increase the difficulty of the general task.

2.2.2 Multiple channels for information processing

As mentioned previously, researchers now believe that there are multiple channels in working memory which are an auditory and a visual channel. The auditory channel handles information that is heard, while the visual channel processes information that is seen. Text seems to have unique processing requirements, with words initially captured by the visual channel and then converted to sounds in the auditory channel [Mayer 2005]. The ability to process information is a multi-step process that involves perception, attention, selection, organization and integration of information [Swan 2003]. The center of this process is long term memory and the long term memory stores accumulated knowledge. Accumulated knowledge is organized into chunks of information in what are known as schema. Schemas allow learner to organize information in meaningful ways and help to integrate and organize new information. In short, the visual channel handles less information than the auditory channel [Miller 1956]. However, when information is presented using both the visual and auditory channels, working memory can handle more information overall.

Using multiple channels can increase the amount of information that the brain can process [Sweller, Ayres and Kalyuga 2008]. However, too much information delivered in an ineffective manner can interfere with the brain’s ability to successfully integrate information into long term memory. Therefore, there is still the risk of cognitive
load. Before information can be integrated into long term memory it must be received and processed by working memory. Humans are limited in the amount of information that can be processed in each channel at one time. When an illustration or animation is presented, the learner is able to hold only a few images in working memory at any time. When a narration is presented, the learner is able to hold only a few words in working memory at any time. Hence it is necessary to provide the instructions in a timely and effective manner.

2.2.3 Mayer’s Instructional Model

Clark and Mayer (2003) declared that the design of e-learning courses should be based on CLT of how people learn and on scientifically valid research studies. To effectively apply cognitive learning theory within e-learning design, they claimed that designers and developers must be well grounded in the critical assumptions the theory makes regarding the human learning process. Cognitive learning theory posits that human memory contains two channels which are visual and auditory in order to processing information. For processing information, the capacity of human memory for processing information is limited. The learning is facilitated through active processing within the memory system and new knowledge and skills must be brought from long-term memory to facilitate a transfer to one’s daily life or profession. Therefore, cognitive learning theory suggests as a fundamental premise that working memory is where all active thinking takes place and represents the center of cognition.

The application of cognitive learning theory principles within e-learning design should be effective due to its explanation of “how mental processes transform information received by the eyes and ears into knowledge and skills in human memory”
Consequently, to maintain e-learning instructional methods must guide the learner's transformation of a lesson's words, pictures, and other instructional material “through the sensory and working memories” [Clark and Mayer 2003]. This is in order to incorporate them within the “existing knowledge in long-term memory” (see Figure 2.1).

![Figure 2.1: Information Processing Model based on Mayer (2005)](image)

### 2.2.4 CLT and Multimedia learning design for principles

There are five major principles of how to use multimedia to help learners understand a scientific explanation [Mayer and Mereno 2003]. These five principles are;

- **Multiple Representation Principle**

  The first principle is simply that it is better to present an explanation using two modes of representation rather than one. People learn better from words and pictures than from word only [Mayer 2002]. This result is the multimedia effects which are consistent with the cognitive theory of multimedia will be able to build two different mental representations. They are the verbal and visual models and learner can build connections between them.
- **Contiguity Principle**

  The second principle is that learners better understand an explanation when corresponding words and pictures are presented at the same time than when they are separated in time. When assigning a multimedia explanation, present corresponding words and pictures contiguously rather than separately. This result is called the contiguity effect. This result is consistent with the cognitive theory of multimedia learning because corresponding words and pictures must be in working memory at the same time. This is for facilitating the construction of referential links between them.

- **Split-Attention Principle**

  The third principle is that words should be presented to the auditory channel rather than visually. When giving a multimedia explanation, it is suggested to present words as auditory narration rather than as visual on-screen text. This result is consistent with the cognitive theory of multimedia learning. This is because the on-screen text and animation can overload the visual information processing system. Whereas narration is processed in the verbal information processing system and animation is processed in the visual information processing system.

- **Individual Differences Principle**

  The fourth principle is the individual differences principle. Multimedia effects, contiguity effects, and split-attention effects depend on individual differences in the learners. The mentioned principles are more important for low knowledge than high-knowledge learners, and for high-spatial rather than low-spatial learners. According to
the cognitive theory of multimedia learning, learners with high prior knowledge may be able to generate their own mental images while listening to an animation or reading a verbal text. Students with high spatial ability are also able to hold the visual image in visual working memory. They are therefore more likely to benefit from the contiguous presentation of words and images.

- **Coherence Principle**

  The fifth principle is that students learn better from a coherent summary which highlights the relevant words and pictures than from a longer version of the summary. When giving a multimedia explanation, it is recommended to use fewer rather than many extraneous words and pictures. A shorter presentation is consistent with the cognitive theory of multimedia learning. This principle primes the learner to select relevant information and organize them productively.

  From these principles, many researchers have been able to study the preliminary principles of multimedia design and all these principles have also been applied to further research. This demonstrates how it is possible to take a learner-centered approach to instructional technology. This can be considered a success to the extent that this line of research contributes to the implementation of successful multimedia instructions development.

**2.3 Experiential Learning (EL)**

Experiential Learning (EL) focuses on doing an activity and then processing that activity from both content and personal perspectives [Gentry 1990]. EL allows learners to make personal and global connections to the learning task. An earlier theorist, John
Dewey, defined a foundation for the EL models that has been used today [Dewey 2005]. It is the importance of making connections between new material and previous experience. This EL models also provided framework for current educational philosophies based on experience and reflection. The EL models of Dewey describes that learners observe and gather information, obtain knowledge by reflecting on initial experiences (see Figure 2.2). From this aspect, learners can offer judgment based on the combination of knowledge and observation. Subsequently, there was the development of the group process model relevant for education supporting Dewey’s definition by Pfieffer and Jones (1980). This model developed originally for group facilitators and has five steps.

First is “Experience” that is the individual experience. The model begins with an experience or activity focusing the attention on the learner rather than the teacher. When the learner is encouraged to learn by doing before told or shown how, opportunities are presented for a wide variety of life skills to be practiced depending on the method used to engage the experience.

Second is “Publishing” that is sharing the individual reactions and observations. As the model shows, sharing is simply asking the group or individuals: What did you do? What happened? What did it feel like to do? This step should generate lots of information to lead to the process step.

Third is “Processing” that is discussing the individual patterns and dynamics. The questions and discussion now become more focused on what was the most important aspect of the activity. Common themes that emerge from the sharing session are explored further.
Fourth is “Generalizing” that is forming the individual board connections and infers principles about the real world which is the challenge or confirmation previously held beliefs.

Fifth is “Applying” that is using the individual information in order to make decisions about future experiences.

![Diagram of Dewey's model](image)

**Figure 2.2:** EL's model of Dewey's model (1980)

Kolb’s (1984) Experiential Learning Theory (ELT) defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience [Kolb 1984]. David Kolb (1984) then extended the research of Dewey and others by theorizing that learning takes place through a four-stage, continuous cycle. This cycle includes (a) concrete experience flowing into (b) reflective observation which stimulates (c) abstract conceptualization that provides ideas for (d) active experimentation [Kolb 1984]. It is the interaction among the parts of this cycle that stimulates learning and
defines the process as holistic and integrative. Kolb suggested that these stages can be seen as an ongoing cycle of learning, integrating, knowing, and doing (see Figure 2.3).

![Figure 2.3: The four modes of Kolb’s Experiential Learning Cycle](image)

In terms of EL in education, it has been focused on the cycle of EL. The experience has mostly referred to the hands-on application of learning. Whether the cycle is made up of three, four, or even five components, the cycle contains more than just an experience or completing a hands-on task. Teacher education programs should continue or begin to include instruction on the entire process of experiential learning not just the importance of a hands-on concrete experience [Beaudin and Quick 1995]. Learning instructional designs should consider that EL is a process and not just simply providing learners with the opportunity to take part in an activity. There must be reflection and opportunity for the student to transfer the learning, that is, the application aspect.
2.4 Summary

The chapter describes the literature review of the Cognitive Load Theory. This includes definitions, types, and their relationships. The VEL framework is developed aiming to reduce cognitive load due to the use of multimedia to learn. This chapter presents the design principles that many researchers have explored and the focused studies on some preliminary principles of multimedia design, leading to the successful implementation of multimedia instructions. Moreover, this research includes EL Technique which provides the framework for current educational philosophies based on experience and reflection. EL is designed for this study in order to reduce cognitive load in learning traffic rules. Chapter Three discusses the research framework employed in this study.
Chapter 3

Research Framework and Hypotheses Development

This chapter discusses the research framework developed in this study for assessing the effectiveness of the VEL framework on educating Thai undergraduate students on traffic rules. The hypotheses are discussed for the evaluation of the learning outcomes from different learning instructional designs for cognitive load reduction in learning.

3.1 Research Framework

The learning instructions being studied in this research consist of four different types of presentations and all of them are based on the same information. The sections of learning traffic rules selected for this study consist of three subsections: Traffic Signs, Alcohol and Drugs, and Speeding Control. They were chosen by the Department of Land and Transport of Thailand in 2011 as they were the main factors associated with road crashes in Thailand. Three sets of pre-test, post-test, and final-test questionnaires were developed and they were based on materials provided by the Department of Land and Transport of Thailand [DLT 2012].

According to Figure 3.1, there were three experimental groups of learning instructional designs involved in the conceptual framework of this study. First was the Traditional Instruction Approach. It was designed to include narration of text, and pictures delivered with Experiential Learning. Second was the Multimedia Instruction Approach. This approach consists of narration of text, pictures, sounds, and 2D
animations delivered with Experiential Learning. The third was the 3D based video instruction approach. Narration of text, pictures, sounds, and 3D videos delivered with Experiential Learning were considered in this way. There was one additional control group which was designed with the instruction comprising narration of text, and pictures delivered without Experiential Learning. The videos were recorded with a 3D camera by recording the real traffic environments in Thailand followed by the rules selected for this study. All virtual instructions were designed based on Mayer’s criteria (1997) for multimedia learning systems to help learners to understand lessons [Mayer and Mereno 2003]. Mayer based the majority of multimedia work on an integration of Sweller’s Cognitive Load Theory which focused on the auditory or verbal channel and visual pictorial channel [Mayer and Mereno 2003].

![Diagram](image)

**Figure 3.1:** Conceptual VEL Framework
It is claimed that multimedia presentations have benefits as they take advantages of both the auditory and visual channels in working memory in order to deliver content [Mayer and Massa 2003]. However, using multiple channels will increase the overall amount of information that the brain has to process. So, effective multimedia delivery needs to recognize that working memory has a limited capacity to handle information. From this aspect, the objective of this study is to determine out the effectiveness of VEL framework on learning instructions as proposed in this study. This research investigated the differences in the learning outcomes between learning instructions delivery with EL and without EL on the learning of traffic rules by Thai undergraduate students. Furthermore, the VEL framework investigated the effectiveness of the EL on cognitive load reduction in the learning of traffic rules by Thai undergraduate students in short term memory and also in long term memory.

3.2 Hypotheses for determining the effectiveness of learning instructions delivery with Experiential Learning

In order to address research question (1) described in Section 1.5, the results due to multimedia teaching design have to be assessed. All the learning instructions delivery with Experiential Learning were investigated with respect to the effectiveness of learning instructional designs that can affect cognitive load reduction on the learning of traffic rules by Thai undergraduate students. This is to find out which learning instructional design is the best for cognitive load reduction both in short term memory and in long term memory. To achieve the objectives of this research, the following null hypotheses were developed as shown in Table 3.1.
**Hypothesis 1**: There is no significant difference between the mean scores from pre-test and post-test using traditional instructions delivered without Experiential Learning. ($H_1: \mu_{post-test} = \mu_{pre-test}$)

**Hypothesis 2**: There is no significant difference between the mean scores from pre-test and post-test using traditional instructions delivered with Experiential Learning. ($H_2: \mu_{post-test} = \mu_{pre-test}$) make up your mind that you want to use hyphen for post- and pre- or not!?

**Hypothesis 3**: There is no significant difference between the mean scores from pre-test and post-test using multimedia instructions delivered with Experiential Learning. ($H_3: \mu_{post-test} = \mu_{pre-test}$)

**Hypothesis 4**: There is no significant difference between the mean scores from pre-test and post-test using 3D based video instructions delivered with Experiential Learning. ($H_4: \mu_{post-test} = \mu_{pre-test}$)

**Hypothesis 5**: There is no significant difference between the mean scores from pre-test and final-test of traditional instructions delivered without Experiential Learning. ($H_5: \mu_{final-test} = \mu_{pre-test}$)

**Hypothesis 6**: There is no significant difference between the mean scores from pre-test and final-test of traditional instructions delivered with Experiential Learning. ($H_6: \mu_{final-test} = \mu_{pre-test}$)

**Hypothesis 7**: There is no significant difference between the mean score of a pre-test and a final-test of multimedia instructions delivered with Experiential Learning. ($H_7: \mu_{final-test} = \mu_{pre-test}$)
Hypothesis 8: There will be no significant difference between the mean score of a pre-test and a final-test of 3D based video instructions delivered with Experiential Learning.  
\( H_8: \mu_{\text{final-test}} = \mu_{\text{pre-test}} \)

Hypothesis 9: There will be no significant difference between the mean score of the post-test of traditional instructions delivered with Experiential Learning and the mean score of the post-test of traditional instructions delivered without Experiential Learning. 
\( H_9: \mu_B = \mu_A \)

Hypothesis 10: There will be no significant difference between the mean score of the post-test of multimedia instructions delivered with Experiential Learning and the mean score of the post-test of traditional instructions delivered without Experiential Learning. 
\( H_{10}: \mu_C = \mu_A \)

Hypothesis 11: There will be no significant difference between the mean score of the post-test of 3D based video instructions delivered with Experiential Learning and the mean score of the post-test of traditional instructions delivered without Experiential Learning. 
\( H_{11}: \mu_D = \mu_A \)

Hypothesis 12: There will be no significant difference between the mean score of the final-test of traditional instructions delivered with Experiential Learning and the mean score of the final-test of traditional instructions delivered without Experiential Learning. 
\( H_{12}: \mu_B = \mu_A \)

Hypothesis 13: There will be no significant difference between the mean score of the final-test of multimedia instructions delivered with Experiential Learning and the mean score of the final-test of traditional instructions delivered without Experiential Learning. 
\( H_{13}: \mu_C = \mu_A \)
**Hypothesis 14:** There will be no significant difference between the mean score of the final-test of 3D based video instructions delivered with Experiential Learning and the mean score of the final-test of traditional instructions delivered without Experiential Learning. \((H_{14}: \mu_D = \mu_A)\)

**Table 3.1:** The Hypotheses for determining the effectiveness of learning instructions delivery with Experiential Learning

<table>
<thead>
<tr>
<th>Research Question 1</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Final-Test</th>
<th>Groups</th>
<th>Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Instruction Performance</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>A</td>
<td>(H_1: \mu_{\text{post-test}} = \mu_{\text{pre-test}})</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>B</td>
<td>(H_2: \mu_{\text{post-test}} = \mu_{\text{pre-test}})</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>C</td>
<td>(H_3: \mu_{\text{post-test}} = \mu_{\text{pre-test}})</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>D</td>
<td>(H_4: \mu_{\text{post-test}} = \mu_{\text{pre-test}})</td>
</tr>
<tr>
<td>Short Term memory</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>A</td>
<td>(H_5: \mu_B = \mu_A)</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>B</td>
<td>(H_6: \mu_C = \mu_A)</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>C</td>
<td>(H_7: \mu_D = \mu_A)</td>
</tr>
<tr>
<td>Long Term memory</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>A</td>
<td>(H_8: \mu_B = \mu_A)</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>B</td>
<td>(H_9: \mu_C = \mu_A)</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>C</td>
<td>(H_{10}: \mu_D = \mu_A)</td>
</tr>
</tbody>
</table>
3.3 Hypotheses for determining the effectiveness of learning instructions on Cognitive Load Reduction

According to Research Question (2) stated in Section 1.5, the results of learning outcomes are used to investigate the effectiveness of learning instructional designs on cognitive load reduction. The VEL framework was designed through the differences in learning outcomes from learning instructions aiming to decrease cognitive load both short term and long term memory. Learning instructions were designed by applying traditional learning instructions, multimedia instructions, and 3D based video instructions for the learning system. A two group’s post-test and final-test experimental design was used to analyze and test hypotheses in this research question as described in Section 1.5. As regard to Research Question (2) Answers are based on the following hypotheses (See Table 3.2).

**Hypothesis 15:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of traditional instructions delivered without Experiential Learning. \( (H_{15}: \mu_{\text{final-test}} = \mu_{\text{post-test}}) \)

**Hypothesis 16:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of traditional instructions delivered with Experiential Learning. \( (H_{16}: \mu_{\text{final-test}} = \mu_{\text{post-test}}) \)

**Hypothesis 17:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of multimedia instructions delivered with Experiential Learning. \( (H_{17}: \mu_{\text{final-test}} = \mu_{\text{post-test}}) \)
**Hypothesis 18:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of 3D based video instructions delivered with Experiential Learning. \((H_{18}: \mu_{\text{final-test}} = \mu_{\text{post-test}})\)

**Hypothesis 19:** There will be no significant difference between the mean score of the post-test of multimedia instructions delivered with Experiential Learning and the mean score of the post-test of traditional instructions delivered with Experiential Learning. \((H_{19}: \mu_C = \mu_B)\)

**Hypothesis 20:** There will be no significant difference between the mean score of the post-test of 3D based video instructions delivered with Experiential Learning and the mean score of the post-test of traditional instructions delivered with Experiential Learning. \((H_{20}: \mu_D = \mu_B)\)

**Hypothesis 21:** There will be no significant difference between the mean score of the post-test of 3D based video instructions delivered with Experiential Learning and the mean score of the post-test of multimedia instructions delivered with Experiential Learning. \((H_{21}: \mu_D = \mu_C)\)

**Hypothesis 22:** There will be no significant difference between the mean score of the final-test of multimedia instructions delivered with Experiential Learning and the mean score of the final-test of traditional instructions delivered with Experiential Learning. \((H_{22}: \mu_C = \mu_B)\)

**Hypothesis 23:** There will be no significant difference between the mean score of the final-test of 3D based video instructions delivered with Experiential Learning and the mean score of the final-test of traditional instructions delivered with Experiential Learning. \((H_{23}: \mu_D = \mu_B)\)
**Hypothesis 24**: There will be no significant difference between the mean score of the final-test of 3D based video instructions delivered with Experiential Learning and the mean score of the final-test of multimedia instructions delivered with Experiential Learning. \( (H_{24}: \mu_D = \mu_C) \)

**Table 3.2**: Hypotheses for determining the effectiveness of learning instructions on Cognitive Load Reduction

<table>
<thead>
<tr>
<th>Research Question 2</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Final-Test</th>
<th>Groups</th>
<th>Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Long Term memory</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>( H_{15}: \mu_{\text{final-test}} = \mu_{\text{post-test}} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_{16}: \mu_{\text{final-test}} = \mu_{\text{post-test}} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_{17}: \mu_{\text{final-test}} = \mu_{\text{post-test}} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_{18}: \mu_{\text{final-test}} = \mu_{\text{post-test}} )</td>
<td></td>
</tr>
<tr>
<td>Short Term memory</td>
<td>/</td>
<td></td>
<td>/</td>
<td>( H_{19}: \mu_C = \mu_B )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_{20}: \mu_D = \mu_B )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_{21}: \mu_D = \mu_C )</td>
<td></td>
</tr>
<tr>
<td>Long Term memory</td>
<td>/</td>
<td></td>
<td>/</td>
<td>( H_{22}: \mu_C = \mu_B )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_{23}: \mu_D = \mu_B )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_{24}: \mu_D = \mu_C )</td>
<td></td>
</tr>
</tbody>
</table>

### 3.4 Hypotheses for determining the effect of satisfaction to learning instructions

Learners’ perceived satisfaction in each learning instruction was measured after finishing the post-test. The purpose was to investigate the levels of participant satisfaction with the learning framework provided. The relationship between learner satisfaction and the tests was analyzed which aimed to measure the influence on
learning outcomes (cognitive load reduction) for learning of traffic rules by Thai undergraduate students. 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 [Chiu et al. 2005]. The questions for these four constructs were adopted from Chui et al.’s Online Learning Continuance Intention Model. Four constructs from Chiu et al.’s model (2005) are shown as follows.

3.4.1 Perceived Usefulness

*Perceived usefulness* is the degree to which a person believes using a particular system would enhance his or her job performance [Davis 1989]. Learner perceived usefulness in learning instructions was defined as the perception of the degrees of improvement in learning effects incorporated in the model being used in this study.

3.4.2 Perceived Ease of Use

*Perceived Ease of Use* demonstrates the degree to which an invention is seen as being not too difficult to understand, learn or operate [Davis 1989]. Perceived Ease of Use in the VEL framework has been defined as the extent to which a participant believes that using a certain learning instruction would be free of effort.

3.4.3 Perceived Value

Learner satisfaction is directly related to *perceived value*. When perceived value increases, learner satisfaction also increases [Chiu, Hsu, Sun, Lin and Sun 2005]. Using perceived value as a measure helps learning system designers to be more aware
of the customer values and working towards meeting the customer goals [Yang and Peterson 2004]. Thus, it is important to include perceived value in the model designed to measure learner satisfaction.

### 3.4.4 Perceived System Quality

*System quality* relates to how productive information is processed within the system [Chiu, Hsu, Sun, Lin and Sun 2005; Yang and Peterson 2004]. System quality together with information quality affects user satisfaction positively [Chiu, Hsu, Sun, Lin and Sun 2005]. Information quality refers to the *relevance, timeliness* and *accuracy* of information generated by an Information System (IS), and it is often measured as a part of user satisfaction. As system quality increases within an IS, user satisfaction also increases [Iivari 2005]. This assumed that the perceived system quality variable positively affects learner satisfaction in learning instructions.

In order to address research question (3) as given in Section 1.5, 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 could be used as a criterion on the assessment of the effectiveness of the learning instructional designs. Answers for research question (3) were therefore based on the following hypotheses (See Table 3.3):

**Hypothesis 25**: There will be no significant difference between the mean score of the learner satisfaction on traditional instructions delivered with Experiential Learning and the mean score of learner satisfaction on traditional instructions delivered without Experiential Learning. ($H_{25}: \mu_B = \mu_A$)
**Hypothesis 26:** There will be no significant difference between the mean score of the learner satisfaction on multimedia instructions delivered with Experiential Learning and the mean score of learner satisfaction on traditional instructions delivered without Experiential Learning. \( (H_{26}: \mu_C = \mu_A) \)

**Hypothesis 27:** There will be no significant difference between the mean score of the learner satisfaction on 3D based video instructions delivered with Experiential Learning and the mean score of the learner satisfaction on traditional instructions delivered without Experiential Learning. \( (H_{27}: \mu_D = \mu_A) \)

**Hypothesis 28:** There will be no significant difference between the mean score of the learner satisfaction on multimedia instructions delivered with Experiential Learning and the mean score of the learner satisfaction on traditional instructions delivered with Experiential Learning. \( (H_{28}: \mu_C = \mu_B) \)

**Hypothesis 29:** There will be no significant difference between the mean score of the learner satisfaction on 3D based video instructions delivered with Experiential Learning and the mean score of the learner satisfaction on traditional instructions delivered with Experiential Learning. \( (H_{29}: \mu_D = \mu_B) \)

**Hypothesis 30:** There will be no significant difference between the mean score of the learner satisfaction on 3D based video instructions delivered with Experiential Learning and the mean score of the learner satisfaction on multimedia instructions delivered with Experiential Learning. \( (H_{30}: \mu_D = \mu_C) \)
### Table 3.3: Hypotheses for determining the effect of satisfaction to learning instructions

<table>
<thead>
<tr>
<th>Research Question 3</th>
<th>Groups</th>
<th>Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Satisfaction measuring</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

#### 3.5 Summary

There are four learning instructions designed for this study on the education of Thai undergraduate on traffic rules. The purpose was to investigate the differences in the learning outcomes on each learning instructions aimed to investigate the effectiveness of the VEL framework on learning instructions on cognitive load reduction in the learning of traffic rules by Thai undergraduate students in short term memory and also in long term memory. The hypotheses were discussed for the evaluation of the learning outcomes from different learning instructions and the satisfaction due to each type of learning instructions.
Chapter 4

Methodology

This chapter addresses the followings: describe the methods used in the study, explain how the materials were prepared for the study, describe the research protocol, explain how measurements were made and what calculations were performed, and state which statistical tests were done to analyze the data. This chapter also includes an extensive discussion of research design, research methodology, and research evaluation, respectively. Firstly, research design has been created to seek answers to the research questions. Secondly, the detailed study of data collection methods is discussed. Finally, the evaluation results are discussed and used to demonstrate the effectiveness of the proposed system.

4.1 Research Design

This study focused on the reduction of cognitive load on educating Thai undergraduate students on traffic rules. The types of research methods were selected according to particular research designs and their corresponding research questions. A quantitative method was chosen for this research study. The study utilized the quasi-experimental design. A quasi-experimental pre-test/post-test control group design was conducted on undergraduate students from one of the private universities in Bangkok. Two sets of pre-test and post-test questionnaires were used to measure participants’ knowledge gained from participating in the experiments. The pre-test and post-test designs are widely used in behavioral research. This is primarily for the purpose of
comparing the mean of two different groups and measuring the change resulting from experimental treatments [Campbell and Stanley 1973].

Figure 4.1: Research Design

4.1.1 Research Phases

To answer the research questions, this study was conducted in a series of four phases. These phases were designed to with interrelationship with each other. Figure 4.2 shows all phases of the study.

Many researches begin with an initial conceptualization of a problem and culminate in the evaluation of the impact of one or more artifacts on ameliorating that problem [Ellis and Levy 2009]. An initial phase of this research work is to review and gather the background information. A review of the literature on cognitive load theory, several techniques for reducing cognitive load, and multimedia learning has been conducted. The purpose of the literature review was to gain an understanding of the current state of knowledge pertaining to research problems. The process of research design for this study was to gather information involved in a road traffic incident at the first stage (See Figure 4.1).
The most current information available in learning process is required in order to understand the problems of road traffic accidents in Thailand and to determine possible ways to solve them. The data were obtained from traffic accident reports in Thailand and the associated traffic rules with focus on young drivers. Information about road traffic was obtained from all accidents and incidents recorded. Such information was provided by the Ministry of Land and transport and relevant organizations. The research problems were explored in order for the design and development of different types of research to present potential solutions and for making a meaningful contribution [Ellis and Levy; Punch 2005]. As mentioned in Chapter One, the proposed
methodology and Virtual Experiential Learning (VEL) were set up to meet the objectives of the problem solving process in order to answer the research questions. Then, identifying a clear purpose helped to determine the hypotheses and goal for this study [De Vaus 2001; Punch 2005]. All the necessary information was gathered from the transport institutions and relevant organizations. For example, Road traffic lessons and questions on the driver’s license test were selected as a case study.

Phase two is about developing the learning instructions. Research methodologies and tools were developed, followed by obtaining the approval from the university research ethic committee. Specifications of the proposed system were designed and developed which were focused upon processing information from the first stage. The design for the proposed learning instructions served to strengthen the interaction in the conceptualization and evaluation cycle [Richey and Klein 2005]. The design of learning instructions was developed based on Mayer’s model and implemented by using web-based applications and graphics software. These learning instructions were accessible via the Internet. The details of the VEL framework were provided in Chapter Three. Approval is granted with the understanding that research is conducted according to the standards of the National Statement on Ethical Conduct in Human Research (2007), the Australian Code for the Responsible Conduct of Research (2007) and relevant research policies from Murdoch University.

For collection and analysis of data, it is important to consider the reliability and validity [Campbell and Stanley 1973; Richey and Klein 2005]. Phase three identifies well-designed and well-conducted pilot studies that can inform the research process and about likely outcomes. Learners’ perceived satisfaction was measured using the
system provided. The validity testing on the instruments was measured by seven responded experts; four lectures of IT in the Universities and three officers from the transport departments in Bangkok. Furthermore, some of the participants were invited to be involved in the testing of the research instruments. The comments and recommendations from the experts, pilot study were indications for the refinement of this research instrument. The learning instructions were redeveloped according to the experts’ evaluation and pilot tests to meet the proposed objectives.

The last phase of the research design is the data collection and analysis process as shown in Figure 4.3. The aim of this phase is to answer the research questions and report the results of the tested hypothesis. The hypotheses were examined based upon the pre-test, post-test, and final-test. The questionnaire was developed in close consultation with senior officers of the Ministry of Land Transport in Thailand. The same questionnaire was used in the control and experimental groups for all the tests. The questionnaire provided a methodical way of comparing results for different groups in different places, at different time. All the participants that qualified were asked to take part in the study via the Internet. The results obtained from the pre-test were used to determine the participants’ knowledge about traffic rules. This offers an accurate means of measurement on representative samples from the respondents. The results of the questionnaires were then used to determine the relations of variables and constructs [Dimitrov and Rumrill 2003]. The post-test questionnaire was conducted after the participants have learnt the lessons of traffic rules. The objective was to measure participants’ knowledge gained from the lessons and to evaluate the effectiveness of the learning instructions. The final-test was applied after finishing the post-test in two weeks. The purpose of the final-test was to assess the proposed model
whether it was able to enable the learners to establish well-organized long term memory according to cognitive load reduction theory. The results of all tests were compared with the measurement of the VEL framework and performance of the learning instructions.

Moreover, learner satisfaction was measured with respect to the learning instructions provided by the VEL framework on educating road traffic in Thailand, that have influences on user’s learning continuance intention. The results yielded a significant effect for enhancing and improving learning effectiveness and learning instruction performance with the aim of reducing cognitive load.

**Figure 4.3:** Two-group pre-test, post-test quasi-experimental designs
4.1.3 Variables

4.1.3.1 Independent variables

The Independent variables of the study are: (1) text and picture's instructions with Experiential Learning, (2) multimedia instructions with Experiential Learning, and (3) 3D based video instructions with Experiential Learning. Each independent variable was presented with EL techniques. These EL techniques provide examples, practices, and exams on each topic. These three independent variables are processed in working memory by comparing how various types of loads such as words and pictures affect selective attention to sensory memory.

4.1.3.2 Dependent variables

One of the dependent variables under consideration was an assessment of cognitive load reduction that was measured from scores based on the pre-test, post-test, and final-test results. The dependent variable was the score from a test obtained in the post-test to measure working memory and final-test to measure long term memory referred to cognitive load reduction. The other dependent variable is the learner satisfactions 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 rules.

4.1.4 Populations and group sampling

The target population of this study was Thai students. They were recruited from undergraduate programs in Bangkok, Thailand. Participants were between the ages of
18 and 25 and at least 400 participants were recruited. Undergraduate students were targeted for the study because the majority of them will apply for a new driver’s license. From the office of the Higher Education Commission's reported in 2010, there are approximately 400,000 undergraduate students in Bangkok, Thailand. This report was used to estimate the number of population size for this study. According to Krejcie and Morgan (1970), the recommended random sample size from a population of 400,000 with a 95% confidence level is 384. 100 participants were invited to take part in the pilot test, 25 participants in each group for measuring the performance of learning instructions and 30 participants for measuring all questionnaires. This number helped to calculate all circumstance that occurred during this study [Holborn et al. 2009]. The participants were separated randomly into control and experimental groups.

At the first stage, demographic data collected consist of e-mail, address, ages, gender, and driver's license. Participants must follow the steps developed for the experiment otherwise the registration cannot be completed. Participants should not hold a driver's license previously. Their ages ranged from 18 to 25 years.

4.2 Data Collection Procedures

In this study, there were four groups that consist of three experimental groups and one control group. Their results were used to compare participants' performance based on different ways of delivering presentations. The control group was set to isolate the independent variable’s effects on the experiment [Punch 2005]. Group A was the control group that was presented with traditional learning instruction provided with only text and images. Additionally, this group was not delivered with EL techniques.
Table 4.1: Lesson Presentation for the five experimental groups and a control group

<table>
<thead>
<tr>
<th>Content Designs</th>
<th>With EL</th>
<th>Without EL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text and Pictures (control group)</td>
<td>Group A</td>
<td></td>
</tr>
<tr>
<td>Text and Pictures</td>
<td>Group B</td>
<td></td>
</tr>
<tr>
<td>Multimedia Instructions</td>
<td>Group C</td>
<td></td>
</tr>
<tr>
<td>3D Based Video Instructions</td>
<td>Group D</td>
<td></td>
</tr>
</tbody>
</table>

The experimental group was the group that independent variables were tested on the group and also the dependent variables were recorded [Punch 2005]. Three experimental groups were group B, group C, and group D. These groups were presented with the learning instructions using three different types of presentations according to three independent variables. These three types of presentation were based on Text and Images Instructions, Multimedia instructions, and 3D based Video Instructions. These groups of learning instructions were presented with EL Techniques. All three experimental groups were developed including the same content of audio files with the text describing the lessons. The audio could be set “On” or “Off” at any time. Three different online learning instructions were developed based on the effect of Cognitive Load Reduction as mentioned in Chapter 3. Three other experimental groups were presented with traditional instructional design with EL comprised narration of text, and pictures (group B); multimedia instructional design with EL comprised narration of text, pictures, sounds, and 2D animations (group C); and 3D based instructional design with EL comprised of narration of text, pictures, sounds, and 3D videos (group D).

Once a participant submitted the demographic survey, the treatment program selected one of the four treatments randomly. The program randomly assigned the participant to one of the four different groups. Once submitted to the treatment program, the demographic data and group assigned were recorded in the database. The e-mail address was used as the username for logging in to the system. This was a developed
web engine for creating and managing the data. According to Figure 4.3, the participants were required to complete the pre-test questionnaires that contained thirty questions. The treatment program allowed the learner to answer five questions shown in a page, and the learner was unable to access the previous page after submitting answers of the pre-test questions. The lessons contained approximately thirty minutes of instructional materials and examples, and practices on each topic were provided to the learners as well. The final-test was conducted after finishing the post-test two weeks later. The participants were reminded to complete the final-test twice, which were one week and two days before the date expired. Participants accessed to the final-test questionnaire once they were logged into the system.

According to learning instruction of the group D’s conditions, 3D glasses were provided for testing the 3D based video lessons. The participants in group D were asked to learn with 3D glasses. If this was inconvenient for them, the 3D grass and the desktop were prepared for the participants in the computer Laboratories of the School of Information Technology and Graduate School of Education at Eastern Asia University and Siam University in Bangkok, Thailand.
4.3 Evaluation

4.3.1 Test validity

Table 4.2 shows the analysis of instruments and statistics used in this study. The statements of evaluation on validity testing are learning instructions and two sections of questions. These questionnaire sections are the question for measuring CLR (pre-test, post-test, and final-test) and questionnaires for measuring learners’ satisfaction on the learning instructions.

Table 4.2: Analysis instruments for validity testing

<table>
<thead>
<tr>
<th>Statements of Evaluation</th>
<th>Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Instructions</td>
<td>5 Likert Scales</td>
</tr>
<tr>
<td>Question for measuring CLR</td>
<td>Item-Objective Congruence (IOC)</td>
</tr>
<tr>
<td>Questionnaires for measuring learner’s satisfaction</td>
<td>Item-Objective Congruence (IOC)</td>
</tr>
</tbody>
</table>

4.3.1.1 Evaluation the learning instructions

To evaluate the effectiveness of the VEL framework, the efficiency of learning instructions was assessed by the experts prior to the launch of the study and to meet the conditions for passing the acceptance tests as regard to the expectations of the instructions’ functionality. Acceptance testing used in this study was the Black Box testing. This test was evaluated by experts before being delivered to the learning systems. “Black box testing is testing that ignores the internal mechanism of a system or component and focuses solely on the outputs generated in response to selected inputs and execution conditions” [Black 2004]. Black box testing technique was used to
examine the high-level design and the user requirements specification to plan the test cases in order to ensure the purposed intention on this study. The application of the three criteria tests for assessing the functional and system testing of learning instructions used in this study was navigation, design, and content. A five-point Likert scale ranging from (1) Strongly Disagree to (5) Strongly Agree was used to rate an expert’s perception on satisfaction of all items. The mean value of all the items was calculated to represent an individual’s score.

4.3.1.2 Test Validity on the questionnaires

Evidence of content validity can be obtained from an evaluation, conducted by a panel of independent experts by evaluating the learning instructions and making a judgment of reviewing the test questions. Thirty multiple questions and satisfaction survey questions were evaluated for the validity testing in this study. An evaluation of the test questions used the Index of Item-Objective Congruence (IOC). The IOC is a process where content experts rate individual items on the degree to which they do or do not measure specific objectives listed by the test developer [Hambleton 1980]. The content experts rate from content specialists that were obtained in order to evaluate the match between test items and the table of specifications [Berk 1984]. Therefore, comments from the subject matter experts were taken into consideration before the test was used for the pilot study.

4.3.2 Test reliability

Table 4.3 presents the analysis of instruments and statistics used in this study. The statements of evaluation on reliability testing are based on the performance of
learning instructions and two sections of questions. Two sections of survey questions are measured repeatedly for the purpose of reliability testing.

**Table 4.3:** Analysis instruments for reliability testing

<table>
<thead>
<tr>
<th>Statements of Evaluation</th>
<th>Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Instructions</td>
<td>5 Likert Scales</td>
</tr>
<tr>
<td>Question for measuring CLR</td>
<td>Item Analysis (Item difficulty index and Item discrimination index), and Internal Consistency (KR-20)</td>
</tr>
<tr>
<td>Questionnaires for measuring learner's satisfaction</td>
<td>5 Likert Scales and Internal Consistency (Cronbach’s Alpha )</td>
</tr>
</tbody>
</table>

**4.3.2.1 Test reliability on the learning instructions**

The learning instructions in this study were evaluated for reliability testing by the pilot study after completing the test validity. The efficiency of learning instructions was measured using the same performance evaluation criteria by the experts based on the expectations of the functionality. Three tested criterions were *navigation, design, and content*, and the acceptance testing used was the *Black Box testing*. A five-point Likert scale ranging from (1) Strongly Disagree to (5) Strongly Agree was used to rate an expert’s perception on satisfaction of all items. The mean value of all the items was calculated to represent an individual’s score.

**4.3.2.2 Test reliability on the questionnaires**

A pilot study was carried out after the learning instructions and the questions were validated. Thirty multiple choices with four alternative answers and satisfactory test questions of the test were analyzed. Test reliability is used to describe the overall consistency of a measure that is defined as the extent to which a questionnaire
produces the same results on repeated trials [Carmines and Zeller 1979]. For a test to be internally consistent, estimates of reliability are based on the average intercorrelations among all the single items within a test [Carmines and Zeller 1979; Drost; Drost 2011]. The reliability of the test was measured with KR-20 (Kuder-Richardson Formula 20). KR-20 is an index of the internal consistency reliability of a measurement instrument, such as a test, questionnaire, or inventory [Streiner 2003]. Internal consistency refers to consistency of learners’ responses across the items on the test [Streiner 2003]. KR-20 was used as a measure of the extent to which items on a test provide consistent information about a learners’ level of knowledge of the road traffic rules from the test. All the items on a test relate to a single content domain. This study expected learners with a very high level of knowledge of the domain to answer most items correctly and students with a very low level of knowledge of the domain to answer most items incorrectly [Golafshani 2003].

For the validity of a measurement instrument, multiple-choice questions are one of the most commonly used tools for assessing knowledge capabilities. The item analysis helps to determine the role of each question with respect to the entire test. Item analysis refers to a mixed group of statistics that are computed for each question on a test. The main purpose of item analysis is to improve the tests by revising or eliminating ineffective items [Sim and Rasiah 2006]. Item analysis was carried out to obtain two types of information to improve the tests for road traffic rules selected for this study. These were the item difficulty index and the item discrimination index. The item difficulty index expresses the proportion or percentage of students who answered the item correctly, whereas the item discrimination index measures the item serves to
discriminate between students with higher and lower levels of knowledge [Cohen et al. 1996].

Furthermore, test questions on the learning instructions were analyzed using the five Likert scale, ranging from (1) Strongly Disagree to (5) Strongly Agree. Also, the Cronbach’s Alpha reliability test for satisfactions was determined through the pilot test. Cronbach’s alpha is calculated for internal consistency reliability which is the average value of the reliability co-efficient where one could obtain for all possible combinations of items [Cronbach 1951; Gay et al. 2006].

4.3.3 The pre-test, post-test, and final-test

After the research instrument has been launched, the next stage was the evaluation for the three tests. The techniques used in this section were pre-test, post-test, and final-test. The questions involved in this research consisted of thirty multiple choice questions. The tests could also be accessed online. As shown in Figure 4.3, the pre-test was the first test, and the purpose was to examine the participant’s prior knowledge and understanding of traffic rules. The researcher could assess the level of knowledge of the participants with the similar background knowledge in this study.

Next, the post-test was conducted, and there were three main purposes for this test. The main purpose was to examine the capacity of learning instructions designed to provide knowledge for the learner. The second purpose was to examine the additional EL technique delivered in the learning instructions aimed to improve the learning system. As for the ultimate purpose, the result score of all groups could be compared to measure which learning instructions could reduce cognitive load in the short term memory.
The final-test was scheduled two weeks later aimed to investigate the performance of the experimental groups to determine whether the learning instructions could cause cognitive load reduction in the long term memory. The result scores were used to compare the learning instructions for improving learning systems.

4.3.4 Satisfaction

A five-point Likert scale ranging from (1) Strongly Disagree to (5) Strongly Agree was used to rate a participant’s perception on satisfaction of all constructs. The mean value of all the items was calculated to represent an individual’s score. A high score indicated that the participant was satisfied with the learning method provided. The internal consistency reliability test was first determined through a pilot test.

4.4 Statistical Analysis

This section describes the statistical tests used to analyze actual data which are test hypotheses of pre-test and post-test scores, test validity, test reliability, and satisfactions. Statistical Package for Social Sciences (SPSS) Version 17 was used to analyze the data in this research. The SPSS was also used to interpret and report the results from the tests. The statistical methods included mean, standard deviation, independent samples t-test, pair samples t-test, and internal consistency reliability. These statistical tests are explained as follows.
4.4.1 Statistical Analysis for Evaluating Learning Instructions for Cognitive Load Reduction

It was anticipated that statistics would be calculated to summarize the population data and describe important data collection methods. Each research question comprises a series of hypotheses in relation to each factor to be measured. Based on the experimental settings, hypothesis testing was used to infer a result of a hypothesis performed on sample data from a larger population. To analyze and test hypotheses of pre-test, post-test, and final-test scores, pair samples t-test and independent samples t-test were used to compare the mean performance scores of the control and experiment groups. The results of these evaluations are presented in Chapter 6.

The pair samples t-test compares the average values of a characteristic measured on a continuous scale between two conditions of the same group [Godfrey 1985]. According to the first research question, the pair samples t-test was used to measure the hypotheses one of four which compared the mean scores of pre-test and post-test of the same group. Moreover, the hypotheses eleven to fourteen also were measured with the pair samples t-test in order to answer Research Question Two. To calculate the parameter, this study used the following formula [Park 2003]:

\[ t = \frac{\bar{d}}{\sqrt{s^2/n}} \]  \hspace{1cm} (4.1)

Where

\[ \bar{d} \] = the mean difference scores between two tests (pre-test and post-test),
\( s^2 \) = the variance of scores,
\( n \) = the number of participants, and
\( t \) = a paired sample t-test with \( n-1 \) degrees of freedom.

Therefore, an alternate formula for paired sample t-test was:

\[
t = \frac{\sum d}{\sqrt{n(\sum d^2) - (\sum d)^2 \over n-1}}
\]

Where \( \sum d \) = sum of the differences
\( \sum d^2 \) = sum of the squared differences (take each difference in turn, square it, and add up all those squared numbers)
\( (\sum d)^2 \) = sum of the differences squared (add up all the differences and square the result)

The square root was \( n \) times the sum of the differences squared minus the sum of the squared differences, all over \( n-1 \).

In addition, the independent samples t-test was used to evaluate the learning instructions in this study. The independent samples t-test compares the average values of a characteristic measured on a continuous scale between two subgroups of a categorical variable [Park 2003]. The independent samples t-test was used to evaluate the hypotheses five to ten for answering the research question one, and the hypotheses fifteen to twenty for answering the research question two. These hypotheses involved the situation where there were two completely different (independent) groups of subjects and the sample size was greater or equal to 100 (\( N = 100 \)). In this situation,
this study compared the means of the two conditions/groups, therefore the formula was [Park 2003]:

\[ t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \]  \hspace{1cm} (4.2)

Where

\( n_1 = \) number of participants in sample 1
\( n_2 = \) number of participants in sample 2
\( \bar{x}_1 = \) mean of scores from sample 1
\( \bar{x}_2 = \) mean of scores from sample 2

Where \( S_1^2 = \) variance of sample 1 = \( \frac{\sum (x_1 - \bar{x}_1)^2}{n_1} \)

\( S_2^2 = \) variance of sample 1 = \( \frac{\sum (x_1 - \bar{x}_2)^2}{n_2} \)

The results were based on a Level of significance \( \alpha = 0.05 \) (5% error).
4.4.2 Statistical analysis for evaluating validity and reliability testing of VEL framework

4.4.2.1 Statistical analysis for evaluating validity testing of VEL framework

Evaluating validity testing was a judgment from the review of the thirty test questions in this study. An evaluation using the index of item objective congruence (IOC) is a process where content experts rate individual items on the degree to which they do or do not measure specific objectives [Hambleton 1980]. Three judges were asked to rank the degree to which the criteria in the instrument measure the objectives that the instrument was designed to measure. A content expert evaluated each item by giving the item a rating of 1 (for clearly measuring), -1 (clearly not measuring), and 0 (degree to which it measures the content area is unclear) for each objective. The results obtained from this test confirmed the content validity of the instrument. The experts assessed the degree to which each objective was being assessed by each item. The method of index of item objective congruence (IOC) was calculated under the following formula [Turner and Carlson 2003].

\[
IOC = \frac{\sum R}{N}
\]

Where \( IOC \) = the congruence between the scales objectives and the items in the scale to measure the self-development of experts

\[ \sum R \] = the total scores of the agreement of experts in each item

\( R \) = the score of the agreement of an expert in each item

\( N \) = total number of experts
Moreover, the items which could be accepted should have IOC values greater than 0.50.

To analyze the rating scale, this used calculating means and standard deviations for data analysis for all the Likert scale testing. The mean is calculated using the following formula [Park 2003].

\[ M = \frac{\sum(x)}{N} \]  

(4.4)

Where \( \Sigma = \text{Sum of} \)

\( X = \text{Individual data points} \)

\( N = \text{Sample size (number of data points)} \)

The standard deviation is calculated using the following formula [Park 2003]:

\[ S^2 = \frac{\sum(x-M)^2}{n-1} \]  

(4.5)

Where \( \Sigma = \text{Sum of} \)

\( X = \text{Individual score} \)

\( M = \text{Mean of all scores} \)

\( N = \text{Sample size (number of scores)} \)

For measuring the results from the Likert scale, this was summarized using the absolute criteria proposed by Best [Best 1981]. Best described the average value on rating scale as shown below:

- 4.51 – 5.00 Very good
- 3.51 – 4.50 Good
4.4.2.2 Statistical analysis for evaluating reliability testing of VEL framework

Reliability is one of the characteristics of a set of test scores. Reliability relates to the stability of measurement over a variety of conditions in which basically the same results should be obtained [Carmines and Zeller 1979]. According to the reliability testing in this study, Kuder Richardson Coefficient of reliability (KR-20) was chosen to evaluate the reliability of a set of scores resulting from the local administration of an assessment instrument. The KR-20 is an index of the internal consistency of the test [Gliem and Gliem 2003; Nunnally]. It is applicable when each question is either right or wrong. A correct question scores 1 and an incorrect question scores 0. The value of KR-20 can range from 0 to 1, with numbers closer to 1 reflecting greater internal consistency. Values of KR-20 for tests are greater than or equal to .70 are acceptable in this study. The general convention in research has been prescribed by Nunnally (1994) who state that one should strive for reliability values of .70 or higher. The formula to compute KR-20 is [Andrich 1982]:

\[
KR_{20} = \frac{K}{K-1} \left[ 1 - \frac{\sum pq}{\sigma_X^2} \right]
\]  

(4.6)

Where \( K \) = number of questions
\( p = \) proportion of learners in the sample who answered question correctly
\( q = \) proportion of learners in the sample who didn’t answer question correctly
\( \sigma^2 = \) variance of the total scores of all the learners who have taken the test

Two types of information on item analysis were analyzed for instrument accuracy was item difficulty index and item discrimination index. First, the *item difficulty index* expresses the proportion or percentage of students who answered the question correctly [Carmines and Zeller 1979]. Item difficulty index can range from 0.0 (none of the learners answered the item correctly) to 1.0 (all of the learners answered the item correctly). Hopkins (1988) articulates that items with a difficulty index between 0.25 and 0.75 are of moderate difficulty [Cao, Theune and Nijholt 2009]. The following formula is used to find the difficulty level [Escudero et al.]:

\[
p = \frac{N_p}{N} \tag{4.7}
\]

Where
\( p = \) the item difficulty index
\( N_p = \) the number of learners who pass the item
\( N = \) the total number of learners in the group

Second is the *item discrimination index* that measures the effectiveness of an item in discriminating between high and low scorers on the whole test [Brennan 1972]. The range of values for the item discrimination index is -1.00 to 1.00. Generally, an item is considered acceptable if the item discrimination index is 0.30 or higher [Brennan 1972]. If the test and an item measure the same ability, this can expect that learners having a high overall test score would have a high probability of being able to answer
the question item. Conversely, this item discrimination index also expects that learners having low test scores would have a low probability of answering the item correctly. Thus, a good item should discriminate between those who score high on the test and those who score low [Reckase 1985]. The formula for the item-discrimination index is:

\[ d = \frac{U_p - L_p}{U} \]  

(4.8)

Where

- \( U_p \) = the numbers of test takers in the upper groups who passed the item,
- \( L_p \) = the numbers of test takers in the lower groups who passed the item
- \( U \) = the total numbers of test takers in the upper group.

### Table 4.4: Guidelines for interpreting item discrimination index (Hopkins, 1998)

<table>
<thead>
<tr>
<th>Discrimination Index, d</th>
<th>Item discrimination evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40 and above</td>
<td>Excellent discrimination</td>
</tr>
<tr>
<td>0.30 to 0.39</td>
<td>Good discrimination</td>
</tr>
<tr>
<td>0.10 to 0.29</td>
<td>Fair discrimination</td>
</tr>
<tr>
<td>0.01 to 0.09</td>
<td>Poor discrimination</td>
</tr>
<tr>
<td>Negative</td>
<td>Item may be mis-keyed or intrinsically ambiguous</td>
</tr>
</tbody>
</table>

### 4.4.2.3 Statistical analysis for measurement of the learning instructions on the VEL framework

From the previous section in this chapter, the efficiency of learning instructions was evaluated by the chosen experts for this study and the learner’s perceived satisfaction on the proposed framework was measured based on answers from the
participants. These were measured using the five Likert scale. The items on a Likert scale consist of statements with which the respondents are expected to differ with respect to the extent to which they agree with them. For each statement, the response scale used 5-point optical scanning response forms in this research as shown in Table 4.5.

**Table 4.5: Rating scale of a Likert Scale**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly disagree</td>
<td>disagree</td>
<td>neutral</td>
<td>Agree</td>
<td>strongly agree</td>
</tr>
</tbody>
</table>

Each judge is required to evaluate each item using the following scale [Allen and Seaman 2007]:

1. = agreeing indicates the respondent is very low in the measured attribute
2. = agreeing indicates the respondent is below average in the measured attribute
3. = agreeing does not tell anything about the respondent’s level of the attribute
4. = agreeing indicates the respondent is above average in the measured attribute
5. = agreeing indicates the respondent is very high in the measured attribute

Additionally, this study applied Cronbach’s Alpha reliability to measure the internal consistency of the test items in the questionnaires. The purpose was to calculate Cronbach’s Alpha reliability co-efficient for the standard of the questionnaires prepared for the pilot test to evaluate the satisfaction on the learning instructions. When using Likert-type scales, it is important to calculate and report, Cronbach’s alpha
coefficient for internal consistency reliability. Likert’s Multi-item scale technique is more imperative to calculate and report Cronbach’s alpha co-efficient for internal consistency reliability for any scales [Gliem and Gliem 2003]. Cronbach’s alpha consistency coefficient, $\alpha$, is defined as [Gay, Mills and Airasian 2006]

$$
\text{Coefficient } \alpha = \frac{K}{K-1} \left[ 1 - \frac{\sum S_i^2}{S_t^2} \right]
$$

(4.9)

Where $K$ = number of separately scored test items/tasks

\[ \sum \] = the operation symbol meaning “the sum of”

$S_i^2$ = variance of students’ scores on a particular test item/task

$\sum S_i^2$ = sum of the item variances for all test items/tasks

$S_t^2$ = variance of the total test scores

The closer Cronbach’s Alpha co-efficient is to 1.00 the greater the internal consistency of the items in the scale. George & Mallory (2003) provides the following guidelines [Gliem and Gliem 2003]:

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\geq 0.9$</td>
<td>Excellent</td>
</tr>
<tr>
<td>$0.8 \leq \alpha &lt; 0.9$</td>
<td>Good</td>
</tr>
<tr>
<td>$0.7 \leq \alpha &lt; 0.8$</td>
<td>Acceptable</td>
</tr>
<tr>
<td>$0.6 \leq \alpha &lt; 0.7$</td>
<td>Questionable</td>
</tr>
<tr>
<td>$0.5 \leq \alpha &lt; 0.6$</td>
<td>Poor</td>
</tr>
<tr>
<td>$\alpha &lt; 0.5$</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>
4.5 Summary

This chapter examined the research methods applied in this study. According to the research problems, and research objectives mentioned in Chapter One, the research approach and research phases have been described. Then, quantitative approaches using pre-test, post-test, and final-test questionnaires were used as the research tools to assess the effectiveness of the learning of instructional designs. The data collection was analyzed using statistical techniques. The following chapter discusses the design and development of the VEL framework and research instruments.
Chapter 5

Design and Development of the VEL Framework

This chapter presents the design and development of the VEL framework. The design of the structure of the learning process is also described in this chapter.

5.1 The Design of VEL Framework

Early research has focused on the constraints of the working memory. Sweller (2008) opined that if the major purpose of instruction is to store information in the long term memory, then cognitive load theory must concern itself with how instruction will facilitate the acquisition of appropriately structured information in the long term memory. Thus, it is necessary for instructional design to take cognizance of how long term memory and short term memory function in human cognitive architecture.

In order to support learners to gain the best results in learning, controlling cognitive load must be considered effectively. The VEL framework was designed to maximize the use of learners working memory resources to access the most effective learning. All virtual instructions should be designed based on Mayer’s criteria (1997) for multimedia learning systems to help students to understand the lessons [Mayer and Mereno 2003]. Mayer based the majority of multimedia work on an integration of Sweller’s Cognitive Load Theory which focused on the auditory or verbal channel and visual pictorial channel [Mayer and Mereno 2003] and this study followed Mayer’s criteria to develop the learning instructions as the research instruments.
Moreover, the use of the VEL framework in this study aimed to assist the learner to retrieve information in order to rethink or reorganize the working memory. This is because retrieval process plays a major role in the recall of information and to increase the efficiency of the storage processes [Cao and Liu 2009]. This research system also used Kolb’s model (1984) which is Experiential Learning (EL). EL involves learning processes associated with learner’s experience and individual learners may adopt different approaches. EL is the process of making meaning from direct experience, and it is also related to the knowledge, skill, and practice obtained from participation or engagement in an activity [Klob 1984; Kolb, Boyatzis and Mainemelis 2000].

EL has four stages in learning which follow from each other as mentioned in Chapter Two (section 2.3). These stages are Concrete Experience, Reflection, Abstract Conceptualization, and Active Experience [Klob 1984]. This study improved learning instructional designs following Kolb’s model using instructional activities (see Figure 5.1). Kolb’s model identifies that learning system must provide explanations of lessons to foster concrete experience [Dunlap et al. 2008]. In addition, learning system should provide examples or practices, tests in each chapter, and final tests [Kolb, Boyatzis and Mainemelis 2000]. Dunlap and his team suggested that e-learning designs should follow Kolb’s model using instructional activities as follows [Dunlap, Dobrovolny and Young 2008]:

- To foster concrete experience by providing explanations of lessons
- To foster reflective observation by providing examples, and practices
- To foster abstract conceptualization by providing tests of each chapter or topic
- To foster active experimentation by providing final test
Figure 5.1: The propose of VEL framework for Cognitive Load Reductions

5.2 Design of the learning process

Road traffic education has a significant effect on the drivers. It is essential to determine the driver behaviors, and this could lead to an improvement of road traffic safety level and minimizes the impacts on the society due to road accidents. In order to
get a better educational method, instructional materials should be analyzed with respect to its effects on short-term memory, long term memory and mental load. This study proposed the use of Virtual Experiential Learning (VEL) to improve learning and aimed to reduce cognitive overload in learning specifically related to educating Thai undergraduate students on road traffic rules. The VEL is a form of virtual learning which combines Experiential Learning techniques (EL) in a framework with multimedia instructions. The learning process was developed according to the design of VEL framework in this research and incorporated in a web-based application.

Road signs in Thailand are similar to those used in many other countries, but some signs are specific and a few of them are written in Thai only. Therefore, the learning instructions were developed for participants using Thai language in order to assist the participants to understand the contents in this study. This is because most of Thai people are not fluent with English language and materials in this study could be used to target the general community later on. An example of traffic signs using Thai language is showed in Table 5.1.
Table 5.1: Example of traffic signs in Thai language

<table>
<thead>
<tr>
<th>Examples of traffic signs</th>
<th>Thai version</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Give way</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stop for inspection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No overtaken zone</td>
</tr>
</tbody>
</table>

The learning instructions were developed using HyperText Markup Language (HTML), HyperText Preprocesor (PHP), and MySQL was the main programming languages for information display on any web browsers. HTML is the set of markup symbols or codes inserted in a file intended for display on a World Wide Web browser page. The markup tells the Web browser how to display a Web page's words and images for the user. PHP is a widely-used open source general-purpose scripting language that is especially suited for web development and can be embedded into HTML. PHP is a server-side scripting language designed for web development. PHP is used together with MySQL for responding to the queries from the users. MySQL is a database management system storing the picture gallery or the vast amounts of information in a corporate network. A database is a structured collection of data and it is used to handle large amounts of data. Figure 5.2 shows an overview of the learning system based on the VEL framework.
Figure 5.2: An overview of learning system based on the VEL framework

Multimedia learning occurs when a learner builds a mental representation from words and pictures that have been presented. For purposes of research program, multimedia instructional messages are presentations of material using words and pictures that are intended to foster learning. The pictures are static graphics such as photos, and tables or dynamic graphics such as 3D based videos or animation.

The VEL framework supports virtual learning which combines EL techniques in the Information Processing Model based on Mayer (2005). The VEL framework was designed with different image representations and comprised of traditional learning instructions, multimedia instructions, and 3D based video instructions. The traditional instructions comprised of narration of text, and pictures. The multimedia instructions comprised of narration of text, pictures, sounds, and 2D animations. The 3D based video instructions comprised of narration of text, pictures, sounds, and 3D videos. The 3D videos were based on the real traffic environments in Thailand relevant to the rules selected for this study.

In order to develop these image formats, HTML was used to support the display of text and images in a variety of heading styles, formats and languages. Adobe
Photoshop, Adobe Premiere Pro, and Macromedia Flash were the main programs used to develop the images used in this study. Adobe Photoshop has been the most popular program for creating and modifying images for the web. Adobe Photoshop has an intuitive user interface, a complete set of tools, and a large number of reference materials available. In addition, Macromedia Flash and scripts were used to provide an interactive multimedia-authoring tool for the creation of the presentations and animations. 3D videos based on real environments were developed using Adobe Premiere Pro, a timeline-based video editing software application.

5.3 Structures of the Learning Processes

There were four learning instructions in this study including one designed without EL technique (control group), and three designed with EL techniques (treatment group). The learning instructions were available to the participants once they have registered. This incorporated security measures of user names and passwords. The structures of learning instruction consisted of lesson learned, examples, practices, and questionnaires. On the other hand, there were examples and practices of lessons learned being put on display for the treatment groups. A summary of learning instructions of the VEL framework is described below:

1. **Lesson learned** – There is information about traffic rules including traffic signs, speed, alcohol, and seat belts. Lesson learned presents text narration and images for describing the information of traffic rules. All groups are given the same text narration describing the traffic rules, but viewing images are different, following the proposal of this study as shown in Figure 5.2 – 5.5.
Figure 5.3: An example screen shot of the lesson learned for group A

Figure 5.4: An example screen shot of the lesson learned for group B
Figure 5.5: An example screen shot of the lesson learned for group C

Figure 5.6: An example screen shot of the lesson learned for group D
2. **Examples** - This part was developed for learning instructions delivered with EL technique, which was provided for participants of group B, C, and D only. The participants were given another image in each traffic rule showing an example environment or incident on the road. Viewing the image depends on the purpose of each group representation. Moreover, a 3D based video was displayed for learners of group D. An example is showed in Figure 5.3 - 5.6.

3. **Practices** – Learners of group B, C, and D were provided with some practices on each topic. Learners were able to test their memory by answering the provided questions. Some questions have images associated to the topic. The answer will display “correct” or “incorrect” with a brief description after the answer was chosen. Some examples of this part are shown in Figure 5.7 – 5.8.
Figure 5.8: An example screen shot of practice section of group B, and C
4. **Questionnaire** – There were three tests involved in this study: pre-test, post-test, and final-test. All tests used the same questions and design in thirty multiple-choice questions. All questions must be answered and the participant cannot redo the previous page. An example of this section is presented in Figure 5.10.
5.4 Summary

This chapter describes the design and development of the VEL framework based on the Mayer's model of cognitive load and multimedia learning. In this study, the developed VEL framework including the EL techniques aimed to reduce cognitive load on learning traffic rules in Thailand. The structure of the learning process consists of lesson learned, example, practices, and a questionnaire. This chapter represents the different design of images of each group experiment which are static images, 2D animation images, and 3D based videos. The results of the testing process of this study are shown in Chapter Six.

Figure 5.10: An example screen shot of the tests
Chapter 6

Research Results and Analysis

This chapter presents the research results and findings of the study in terms of three main sections. In the first section, results from the test of validity and reliability on instruments are discussed. In the second section, results from the tests of 4 participant groups after completed the learning instructions are elaborated in more detail. In the third section, results from the learners’ satisfaction on the learning instructions are given.

The aims of the finding are listed as follows;

- to investigate the performance of applying EL on the learning instructions
- to find out the effectiveness of the VEL concept applied to the learning instructions on short term memory with respect to cognitive load reduction (CLR)
- to find out the effectiveness of the VEL concept applied to the learning instructions on long term memory with respect to cognitive load reduction (CLR)
- to find out the learners’ satisfaction on learning instructions based on the proposed VEL framework in this study

6.1 Results of validity and reliability

6.1.1 Results of validity

In this study, validity was used to measure the two issues: the learning instructions designed, and the questions used for evaluating the proposed model. Five lecturers in IT and five qualified transport officers were recruited to analyze the
instruments. The validity testing on the instruments was measured by seven experts: four university lecturers in IT and three officers from the transport departments in Bangkok. They had completed and returned the questionnaires.

The learning instructions were measured based on the efficiency of the VEL framework approved by the experts before being launched. This was done in order to check the delivery acceptance tests compatible with the expectations of the functionality. The Black Box testing approach was used to examine three criteria: navigation, design, and content. A five-point Likert scale ranging from (1) Strongly Disagree to (5) Strongly Agree was used to rate an expert’s perception on the acceptance of all items. The results of the assessment of the learning instructional designs as illustrated in Chapter Five are shown in Table 6.1. For Group A, the assessment level of three criterions was in a good level with average scores for navigation, design, and content as 3.85, 3.71, and 3.98, respectively. The results of Group B were 3.98, 4.17, and 4.17 for the three criteria. The results showed good level for all criteria with respect to the efficiency of the learning instructions. For Group C, the evaluation results were the same as Group B and they were in good level for all criteria with values of the average scores as 4.29, 4.30, and 4.24 respectively. The average scores of Group D were 4.55, and 4.50 for criteria navigation and design which represented a very good level. The average score of the criterion content was 4.24 which meant a good level for this learning instruction.
Table 6.1: Validity testing for evaluation learning instructions

<table>
<thead>
<tr>
<th>Group</th>
<th>Evaluation Results</th>
<th>Navigation</th>
<th>Design</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>M</td>
<td>3.85</td>
<td>3.71</td>
<td>3.98</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.56</td>
<td>0.59</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>B</td>
<td>M</td>
<td>3.98</td>
<td>4.17</td>
<td>4.17</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.63</td>
<td>0.58</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>M</td>
<td>4.29</td>
<td>4.3</td>
<td>4.24</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.52</td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>D</td>
<td>M</td>
<td>4.55</td>
<td>4.5</td>
<td>4.45</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.56</td>
<td>0.64</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

In the next step, 30 questions and satisfaction test questions were evaluated based on the validity testing of the objectives 1 and 2. The validity testing of a test score is always an important and significant step within the process of standardization of any scale. However, it depends on the extent of efficiency with what and which measures attempting to measure. After the experts completed an evaluation of the items, the ratings were combined to provide indices of Item-Objective Congruence (IOC) measures for each item on each of the objectives. Firstly, an evaluation of the 30 questions was used through the Index of Item-Objective Congruence (IOC). Objectives 1 and 2 were a test for measuring CLR with the average index value of IOC from 0.57 to 1.00 derived from all experts. According to research objective 1, the item 3, 4, and 10 to 12 had lower index values than the other items at 0.57. There were some experts who did not clearly agree on these items while measuring objective 1. But, there were
some other experts who also agreed on the fact that the item is clearly measuring this objective. Next, the highest average index value 1.00 of the objective 2 was observed in the items 5 and 7. Additionally, the lowest average index value 0.57 of the objective 2 was observed in the items 2, 4, 9, 15, 17, and 27. The highest average index value of 1.00 was observed in item 5.

Furthermore, the IOC was used to measure the questionnaires for evaluating learner satisfactions by the 7 experts. The results showed that all of the items had the range of the average index value of 0.57 to 1.00 for the third research objective. There were 10 from 57 items that had the lowest average index value. These items were 2, 8, 10, 14, 16, 18, 29, 45, 49, and 53. Also the highest average index value of 1.00 was observed in items 5, 11, 17, and 21. Typically, all items were in the acceptable range of values for an analysis using 7 content experts.

### 6.1.2 Results of reliability testing

The reliability testing in this study was measured in three parts. After completing the validity testing, all instruments were measured again through the pilot study. This section also measured the learning instructions, 30 questions, and questionnaire of satisfaction. These were used for evaluating the learning instructions.

As mentioned earlier, the learning instructions were measured as an instrument of the research via a pilot study. The reliability testing also was used to measure two issues: the learning instructions designed, and the questions used for evaluating the VEL framework. The learning instructions were measured by the efficiency of the VEL framework before being launched. In total, 100 students were randomly chosen from
the name lists of 4 classes in the Information Technology unit of Siam University, Bangkok Thailand. They were invited to participate in the computer laboratory class. Three criteria: navigation, design, and content were measured using a five-point Likert scale to rate an expert's perception on the acceptance of all items. As shown in Table 6.2, the mean scores for navigation, design, and content were from 3.81 to 4.45. The results showed good level for all criterions of the efficiency of learning instructions.

Again, 30 questions were examined for the reliable instruments in order to evaluate the test's effectiveness. The goal of item analysis was to help improving the test by revising or discarding ineffective items [Carmines and Zeller 1979]. 30 participants completed the questionnaires. They were all from the undergraduate students in two separated classes and they must hold driver license. Item analysis for instrument accuracy was based on the item difficulty index and item discrimination index.
Table 6.2: Reliability testing for evaluation learning instructions

<table>
<thead>
<tr>
<th>Group</th>
<th>Evaluation Results</th>
<th>Navigation</th>
<th>Design</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>M</td>
<td>3.83</td>
<td>3.85</td>
<td>3.95</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.69</td>
<td>0.68</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>B</td>
<td>M</td>
<td>3.92</td>
<td>3.93</td>
<td>4.01</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.64</td>
<td>0.71</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>M</td>
<td>4.01</td>
<td>4.00</td>
<td>4.45</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.70</td>
<td>0.78</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>D</td>
<td>M</td>
<td>3.81</td>
<td>3.81</td>
<td>3.91</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.68</td>
<td>0.70</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

Item difficulty can be defined as the proportion of the examinees that marked the item correctly. Item difficulty is the percentage of students that correctly answered the item, also referred to as the *p*-value [Turner and Carlson 2003]. The range of *p*-value is from 0% to 100%. *P*-values above 0.90 are very easy items and might be a concept not worth testing. *P*-values below 0.20 identify difficult items. The values from 0.20 to 0.90 indicate an acceptance of items. If the value is outside the range, it should then be reviewed. This may be caused by unclear language or the contents need to be refined. In this study, the results showed that item difficulty ranges from 0.39 to 0.72. Classifying the items according to their difficulty level, this study grouped the *p*-value together in the manner as shown in Table 5.3. The table presented the percentages of the classification of the item difficulty index based on the classification of the *p*-value.
Table 6.3: Classification of the p-value

<table>
<thead>
<tr>
<th>P-values</th>
<th>Percentages</th>
<th>Classification of the p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 – 0.44</td>
<td>23.33 %</td>
<td>Moderately difficulty</td>
</tr>
<tr>
<td>0.45 – 0.64</td>
<td>53.34 %</td>
<td>Medium difficulty</td>
</tr>
<tr>
<td>0.65 - 0.84</td>
<td>23.33 %</td>
<td>Moderately easy</td>
</tr>
</tbody>
</table>

For the item-discrimination index (\(d\)), Item discrimination refers to the degree to which success or failure on an item indicates possession of the ability being measured. This value ranges between 0.0 and 1.00. This study identified upper 27% and lower 27% examinees that had the highest and the lowest scores in sequence and respectively on the total test. For the discrimination index, the upper and lower groups were formed from the top 9 and bottom 9 test takers on total test score. The results of item discrimination analysis showed that Item 6, 11, 13, 20, 24, and 26 were the lowest value of discrimination with 0.33. But item discrimination evaluation still manifested a Good discrimination. Item discrimination evaluation illustrated excellent discrimination for the rest of the items. And the highest value of discrimination was 0.89 for item 9, and 22.

Next, the questions were measured based on the internal consistency using KR-20. Internal consistency concerns the extent to which items on the test or instrument are measuring the same thing. Internal consistency is estimated via the *split-half* reliability index. The value of KR-20 ranges from 0 to 1, and numbers closer to 1 reflecting greater internal consistency. Values of KR-20 are greater than or equal to 0.70 are acceptable. Hence, the value of KR-20 in this study was 0.88 which considered to be quite acceptable, and this was an indicator of a great internal consistency. Consequently, all thirty questions represented good results of reliability.
testing. This is probably because of the fact that all questions were selected by the officers from actual driving tests in Thailand.

Moreover, 57 questions of satisfying evaluation were required to be measured for the reliability testing. This study used the five Likert scale, ranging from (1) Strongly Disagree to (5) Strongly Agree. In total, 30 undergraduate students were invited to contribute in the pilot study in this part. Cronbach’s alpha is calculated for internal consistency reliability, and the Cronbach’s alpha for all 57 items was 0.816. This was considered reliable and had good internal consistency (see Table 6.4). There is, therefore, sufficient evidence to support the fact that the individual variables identified in the reliability analysis were good measures of the questionnaires.

Table 6.4: Cronbach’s alpha with 57 items

<table>
<thead>
<tr>
<th>No of Correct Responses</th>
<th>Cronbach’s Alpha with 57 Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0.816</td>
</tr>
</tbody>
</table>

6.2 Characteristics of Participants

This section elaborates more on the participants recruited for this study. In general, 444 undergraduate students from private universities in Bangkok, Thailand participated in this study. All of the participants were selected according to the demography’s requirements. The demography information of participants required contained the following: e-mail address, ages, gender, and driver license status. Each participant used an internet browser on a computer connected to the Internet to participate in the study. The participants were from private universities in Bangkok,
Thailand. All the participants must have no driver licenses and the average age of participants is presented in Table 5.5. Those participants who were not in these two requirements could not participate in this study. Once a participant submitted the demography survey, the treatment program selected 1 of 4 groups of learning instructional designs. The participants were separated randomly into control and experiment groups.

**Table 6.5: Information about the participants**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Female</th>
<th>Number of Male</th>
<th>Average Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>63</td>
<td>38</td>
<td>19.31</td>
</tr>
<tr>
<td>B</td>
<td>69</td>
<td>45</td>
<td>19.37</td>
</tr>
<tr>
<td>C</td>
<td>68</td>
<td>40</td>
<td>19.39</td>
</tr>
<tr>
<td>D</td>
<td>64</td>
<td>57</td>
<td>19.42</td>
</tr>
</tbody>
</table>

**6.3 Results from the Pre-test**

After all the participants finished the pre-questionnaire process, they were assessed with the pre-test. This study selected the participants who gained similar scores among the groups in the pre-questionnaire. This was because the results of pre-questionnaire provided the assessment and investigation of the participants’ knowledge background on the traffic rules. The targeted number of the participants in each group was at least 100 learners.

One control (group A) and three treatment groups (group B, C, D) were investigated for 4 learning instructional designs. The results showed that all the chosen
participants had similar knowledge background on traffic rules based on a set of pre-test questions, as illustrated by the average scores from the pre-test (see Table 6.6).

Table 6.6: Pretest comparing for knowledge background

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Average</th>
<th>Variance</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>101</td>
<td>10.99</td>
<td>5.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>114</td>
<td>11.05</td>
<td>3.78</td>
<td>0.026</td>
<td>0.994</td>
</tr>
<tr>
<td>C</td>
<td>108</td>
<td>11.06</td>
<td>3.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>121</td>
<td>11.02</td>
<td>2.29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the other hand, it is important to compare knowledge background of the participants. It is obvious that different kinds of background knowledge can result in different achievements individually. The results of pre-test score of 4 groups are presented in Table 6.6. The mean scores of the pre-test of group A to D were 10.99, 11.05, 11.06, and 11.02 respectively. To determine an existence of a significant difference between any of the means, one could compare each possible pair of means individually [Miller Jr 1997]. Therefore, a one-way ANOVA approach was used in order to analyze the mean of pre-test scores for all of the groups. A one-way ANOVA is a statistical technique enabling to test whether three or more means are equal. It tests the value of a single variable differs significantly among three or more levels of a factor. In Table 6.6, the \( p\text{-value} \) of 0.994 indicates the fact that there were not significantly differences between the pre-test of all experimental groups.

6.4 Testing of Hypotheses

This section reports the results gathered from the data analysis of the quasi-experimental study. The analyses were carried out through various statistical
techniques such as the descriptive statistics analysis, the independent samples t-test and the pair sample T-Test. In addition, a five-point Likert scale was used in order to rate a participant’s perception on satisfaction of all constructs. Accordingly the section presents the results of the hypotheses testing according to the research questions.

1. Does EL affect cognitive load reduction on learning of traffic rules by Thai undergraduate students?

2. Are there any differences in learning outcomes (cognitive load reduction) for learners between traditional learning instructions, multimedia instructions, and 3D based video instructions on educating Thai undergraduate students on traffic rules?

3. Does satisfaction on learning instructions have an influence on learning outcomes (cognitive load reduction) on learning of traffic rules by Thai undergraduate students?

The results of these research questions were analyzed from learning outcomes and user satisfaction of the tests shown in Figure 6.1. Each of the hypotheses compares the difference result scores to measure the effectiveness of learning instructions influencing to reduce cognitive load in learning. Figure 6.1 shows the summary of the testing scores of pre-test, post-test, and final-test including scores of user satisfaction of all experimental groups. The results of testing hypotheses are described below.
6.4.1 Testing hypotheses 1 to 14

With respect to Research Question One, it was realized that EL had an effect on cognitive load reduction on learning of traffic rules. EL was investigated for cognitive load reduction based on the both short term and long term memory. Due to the limitation of working memory, it can only manage small amounts of information before it has to be integrated into long term memory or lost. Therefore, applying EL techniques into the learning instructions help short term or working memory to be enabled to handle more information overall. The capacity of learning instructions for gaining knowledge was tested in the learning of the designed lessons. Long term memory is
where information is stored and where it integrates new information [Paas, Tuovinen, Tabbers and Van Gerven 2003]. Learning can be thought of as a change in the long term memory. EL was investigated by measuring the test scores from the final-test in this study.

Table 6.7 shows the effectiveness of EL on cognitive load reduction based on analysis of the post-test results. This table illustrates the hypotheses 1 to 4 and statistical analysis using the pair sample t-test. The comparison of the pre-test and the post-test score found that the average scores of the post-test of every groups were significantly higher than the pre-test score of every groups with statistically value at 0.05.

**Table 6.7: The results of the Pair Sample T-Test for hypotheses 1 to 4**

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>Sig. (2-tailed)/2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>H₁: μ&lt;sub&gt;post-test&lt;/sub&gt; = μ&lt;sub&gt;pre-test&lt;/sub&gt;</td>
<td>A</td>
<td>101</td>
<td>10.99</td>
<td>18.28</td>
<td>2.36</td>
<td>2.14</td>
</tr>
<tr>
<td>H₂: μ&lt;sub&gt;post-test&lt;/sub&gt; = μ&lt;sub&gt;pre-test&lt;/sub&gt;</td>
<td>B</td>
<td>114</td>
<td>11.05</td>
<td>21.02</td>
<td>1.95</td>
<td>2.39</td>
</tr>
<tr>
<td>H₃: μ&lt;sub&gt;post-test&lt;/sub&gt; = μ&lt;sub&gt;pre-test&lt;/sub&gt;</td>
<td>C</td>
<td>108</td>
<td>11.06</td>
<td>24.06</td>
<td>1.95</td>
<td>2.00</td>
</tr>
<tr>
<td>H₄: μ&lt;sub&gt;post-test&lt;/sub&gt; = μ&lt;sub&gt;pre-test&lt;/sub&gt;</td>
<td>D</td>
<td>121</td>
<td>11.02</td>
<td>23.41</td>
<td>1.51</td>
<td>2.18</td>
</tr>
</tbody>
</table>

Level of significance α = 0.05 (5% error)

**Hypothesis 1:** There will be no significant difference between the mean score of a pre-test and a post-test of traditional instructions delivered without EL. (H₁: μ<sub>post-test</sub> = μ<sub>pre-test</sub>)

The results showed a comparison of the mean score of the pre-test (M = 10.99, SD = 2.36) and the post-test (M= 18.28, SD = 2.14) of group A. The average score of
the post-test was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 1 was rejected.

**Hypothesis 2:** There will be no significant difference between the mean score of a pre-test and a post-test of traditional instructions delivered with EL. \( H_2: \mu_{\text{post-test}} = \mu_{\text{pre-test}} \)

The results showed the comparison of the mean score of the pre-test \( (M = 11.05, SD = 1.95) \) and the post-test \( (M = 21.02, SD = 2.39) \) of group B. The average score of the post-test was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 2 was rejected.

**Hypothesis 3:** There will be no significant difference between the mean score of a pre-test and a post-test of multimedia instructions delivered with EL. \( H_3: \mu_{\text{post-test}} = \mu_{\text{pre-test}} \)

The results showed the comparison of the mean score of the pre-test \( (M = 11.06, SD = 1.95) \) and the post-test \( (M = 24.06, SD = 2.00) \) of group C. The average score of the post-test was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 3 was rejected.

**Hypothesis 4:** There will be no significant difference between the mean score of a pre-test and a post-test of 3D based video instructions delivered with EL. \( H_4: \mu_{\text{post-test}} = \mu_{\text{pre-test}} \)

The results showed the comparison of the mean score of the pre-test \( (M = 11.02, SD = 1.51) \) and the post-test \( (M = 23.41, SD = 2.18) \) of group D. The average score of
the post-test was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 4 was rejected.

In Table 6.8, the final-test analyzed the effectiveness of EL on cognitive load reduction according to the hypotheses 5 to 8. The statistical analysis method used was the pair sample t-test. The comparision of the pre-test and the final-test score found that the average score of the final-test of every groups were significantly higher than the pre-test score of every groups with statistically value at 0.05.

**Table 6.8: The results of the Pair Sample T-Test for hypotheses 5 to 8**

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Group</th>
<th>N</th>
<th>Mean Pre-test</th>
<th>Mean Final-test</th>
<th>SD Pre-test</th>
<th>SD Final-test</th>
<th>t</th>
<th>Sig.(2-tailed)/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_5: \mu_{\text{final-test}} = \mu_{\text{pre-test}}$</td>
<td>A</td>
<td>101</td>
<td>10.99</td>
<td>16.83</td>
<td>2.36</td>
<td>2.97</td>
<td>-15.29</td>
<td>0.000</td>
</tr>
<tr>
<td>$H_6: \mu_{\text{final-test}} = \mu_{\text{pre-test}}$</td>
<td>B</td>
<td>114</td>
<td>11.05</td>
<td>17.89</td>
<td>1.95</td>
<td>2.67</td>
<td>-24.74</td>
<td>0.000</td>
</tr>
<tr>
<td>$H_7: \mu_{\text{final-test}} = \mu_{\text{pre-test}}$</td>
<td>C</td>
<td>108</td>
<td>11.06</td>
<td>19.69</td>
<td>1.95</td>
<td>2.42</td>
<td>-29.77</td>
<td>0.000</td>
</tr>
<tr>
<td>$H_8: \mu_{\text{final-test}} = \mu_{\text{pre-test}}$</td>
<td>D</td>
<td>121</td>
<td>11.02</td>
<td>20.96</td>
<td>1.51</td>
<td>3.17</td>
<td>-33.65</td>
<td>0.000</td>
</tr>
</tbody>
</table>

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

**Hypothesis 5:** The results showed the comparison of the mean score of the pre-test ($M = 10.99, SD = 2.36$) and the final-test ($M = 16.86, SD = 2.97$) of group A. The average score of the final-test of was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 5 was rejected.

**Hypothesis 6:** The results showed the comparison of the mean score of the pre-test ($M = 11.05, SD = 1.95$) and the final-test ($M = 17.89, SD = 2.67$) of group B. The average score of the final-test of was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 6 was rejected.
Hypothesis 7: The results showed the comparison of the mean score of the pre-test ($M = 11.06$, $SD = 1.95$) and the final-test ($M = 19.69$, $SD = 2.42$) of group C. The average score of the final-test of was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 7 was rejected.

Hypothesis 8: The results showed the comparison of the mean score of the pre-test ($M = 11.02$, $SD = 1.51$) and the final-test ($M = 20.96$, $SD = 3.17$) of group D. The average score of the final-test of was significantly higher than the pre-test score with statistically value of 0.00. In conclusion, hypothesis 6 was rejected.

Consequently, the learning instructions were investigated with respect to the extent of reduction on cognitive load in short term and long term memory. Four learning instructions were designed with different interfaces but the same contents. Hypotheses 9 to 14 were analyzed using the mean score of post-test and final-test between groups in order to examine the performance of different learning instructions delivered with EL (group B, C, D) and without EL (group A). The results of mean score and standard deviation of all groups are shown in Table 6.9.

**Table 6.9: Summary of the mean score of the tests**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Final-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>A</td>
<td>10.99</td>
<td>2.36</td>
<td>18.28</td>
</tr>
<tr>
<td>B</td>
<td>11.05</td>
<td>1.95</td>
<td>21.02</td>
</tr>
<tr>
<td>C</td>
<td>11.06</td>
<td>1.95</td>
<td>24.06</td>
</tr>
<tr>
<td>D</td>
<td>11.02</td>
<td>1.51</td>
<td>23.41</td>
</tr>
</tbody>
</table>

Table 6.9 also presents the mean score of the post-test of the experimental groups (B, C, D) which were higher than the control group (A). The results indicate that
hypotheses 9 to 14 of research question 1 were rejected significantly at the 0.05 level (see Table 6.10).

**Table 6.10**: Results of the Independent Samples T-Test for hypotheses 9 to 14

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Levene’s Test for Equality of Variances</th>
<th>T</th>
<th>df</th>
<th>Sig (2-tailed)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_9 : \mu_{\text{post-testB}} = \mu_{\text{post-testA}}$</td>
<td>$F = 1.25$</td>
<td>$T = -8.82$</td>
<td>213</td>
<td>$.000$</td>
</tr>
<tr>
<td>$H_{10} : \mu_{\text{post-testC}} = \mu_{\text{post-testA}}$</td>
<td>$F = 1.15$</td>
<td>$T = -20.18$</td>
<td>207</td>
<td>$.000$</td>
</tr>
<tr>
<td>$H_{11} : \mu_{\text{post-testD}} = \mu_{\text{post-testA}}$</td>
<td>$F = 1.04$</td>
<td>$T = -17.63$</td>
<td>220</td>
<td>$.000$</td>
</tr>
<tr>
<td>$H_{12} : \mu_{\text{final-testB}} = \mu_{\text{final-testA}}$</td>
<td>$F = 1.24$</td>
<td>$T = -2.77$</td>
<td>213</td>
<td>$.006$</td>
</tr>
<tr>
<td>$H_{13} : \mu_{\text{final-testC}} = \mu_{\text{final-testA}}$</td>
<td>$F = 1.51$</td>
<td>$T = -7.67$</td>
<td>207</td>
<td>$.000$</td>
</tr>
<tr>
<td>$H_{14} : \mu_{\text{final-testD}} = \mu_{\text{final-testA}}$</td>
<td>$F = 1.14$</td>
<td>$T = -9.94$</td>
<td>220</td>
<td>$.000$</td>
</tr>
</tbody>
</table>

* Level of significance $\alpha = .05$

**Hypothesis 9**: There will be no significant difference between the mean score of the post-test of traditional instructions delivered with EL (group B) and the mean score of the post-test of traditional instructions delivered without EL (group A). ($H_9 : \mu_{\text{post-testB}} = \mu_{\text{post-testA}}$)

The result showed that there were statistically significant difference in the post-test score between group B ($M = 21.02$, $SD = 2.39$) and group A ($M=18.28$, $SD = 2.14$) with statistically value of 0.00 (see Table 6.8, 6.9). The average score of the post-test of group B was significantly higher than the post-test of group A. In conclusion, hypothesis 9 was rejected.

**Hypothesis 10**: There will be no significant difference between the mean score of the post-test of multimedia instructions delivered with EL (group C) and the mean score of the post-test of traditional instructions delivered without EL (group A). ($H_{10} : \mu_{\text{post-testC}} = \mu_{\text{post-testA}}$)
The result showed that there were statistically significant difference in the post-test score between group C \((M = 24.06, SD = 2.00)\) and group A \((M=18.28, SD = 2.14)\) with statistically value of 0.00 (see Table 6.8, 6.9). The average score of the post-test of group C was significantly higher than the post-test of group A. In conclusion, hypothesis 10 was rejected.

**Hypothesis 11:** There will be no significant difference between the mean score of the post-test of 3D based video instructions delivered with EL (group D) and the mean score of the post-test of traditional instructions delivered without EL (group A). \((H_{11} : \mu_{\text{post-testD}} = \mu_{\text{post-testA}})\)

The result showed that there were statistically significant difference in the post-test score between group D \((M = 23.41, SD = 2.18)\) and group A \((M=18.28, SD = 2.14)\) with statistically value at 0.00 (see Table 6.8, 6.9). The average score of the post-test of group D was significantly higher than the post-test of group A. In conclusion, hypothesis 11 was rejected.

Moreover, the EL was examined against the effectiveness in long term memory with the final-test, and the results showed that the mean score of the learning instructions with the EL were higher than the learning instruction without the EL. Accordingly, the hypotheses 12 to 14 were rejected with level of significance \(\alpha = .05\). This showed that the EL affected cognitive load reduction in long term memory.

**Hypothesis 12:** There will be no significant difference between the mean score of the final-test of traditional instructions delivered with EL (group B) and the mean score of the final-test of traditional instructions delivered without EL (group A). \((H_{12} : \mu_{\text{final-testB}} = \mu_{\text{final-testA}})\)
The result showed that there were statistically significant difference in the final-test score between group B (M = 17.89, SD = 2.67) and group A (M=16.83, SD = 2.97) with statistically value of 0.006 (see Table 6.8, 6.9). The average score of the final-test of group B was significantly higher than the final-test of group A. In conclusion, hypothesis 12 was rejected.

**Hypothesis 13:** There will be no significant difference between the mean score of the final-test of multimedia instructions delivered with EL (group C) and the mean score of the final-test of traditional instructions delivered without EL (group A). \( (H_{13} : \mu_{\text{final-test}_C} = \mu_{\text{final-test}_A}) \)

The result showed that there were statistically significant difference in the final-test score between group C (M = 19.69, SD = 2.42) and group A (M=16.83, SD = 2.97) with statistically value of 0.00 (see Table 5.8, 5.9). The average score of the final-test of group C was significantly higher than the final-test of group A. In conclusion, hypothesis 13 was rejected.

**Hypothesis 14:** There will be no significant difference between the mean score of the final-test of 3D based video instructions delivered with EL (group D) and the mean score of the final-test of traditional instructions delivered without EL (group A). \( (H_{14} : \mu_{\text{final-test}_D} = \mu_{\text{final-test}_A}) \)

The result showed that there were statistically significant difference in the final-test score between group D (M = 20.96, SD = 3.17) and group A (M=16.83, SD = 2.97) with statistically value of 0.00 (see Table 6.8, 6.9). The average score of the final-test of group B was significantly higher than the final-test of group A. In conclusion, hypothesis 14 was rejected.
6.4.2 Testing hypotheses 15 to 24

According to Research Question Two, this research question attempts to investigate the effectiveness of learning instructional designs on cognitive load reduction. The VEL framework was designed through the differences in the learning outcomes from learning instructions to educating Thai undergraduate students on traffic rules. Learning instructions were designed by applying traditional learning instructions, multimedia instructions, and 3D based video instructions to the learning system. This aimed to decrease cognitive load both short term and long term memory. A two group’s post-test and final-test experimental design were employed to analyze and test hypotheses in this research question. SPSS was used to analyze the data. Pair Sample T-Test and the Independent Samples T-Test were used to prove the significance of the variables as shown in Tables 6.11 and 6.12, respectively.

Table 6.11: Results of the Pair Sample T-Test for hypotheses 15 to 18

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>Sig. (2-tailed)/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{15}: \mu_{\text{final-test}} = \mu_{\text{post-test}}$</td>
<td>A</td>
<td>101</td>
<td>18.28</td>
<td>16.83</td>
<td>2.14</td>
<td>2.97</td>
</tr>
<tr>
<td>$H_{16}: \mu_{\text{final-test}} = \mu_{\text{post-test}}$</td>
<td>B</td>
<td>114</td>
<td>21.02</td>
<td>17.89</td>
<td>2.39</td>
<td>2.67</td>
</tr>
<tr>
<td>$H_{17}: \mu_{\text{final-test}} = \mu_{\text{post-test}}$</td>
<td>C</td>
<td>108</td>
<td>24.06</td>
<td>19.69</td>
<td>2.00</td>
<td>2.42</td>
</tr>
<tr>
<td>$H_{18}: \mu_{\text{final-test}} = \mu_{\text{post-test}}$</td>
<td>D</td>
<td>121</td>
<td>23.41</td>
<td>20.96</td>
<td>2.18</td>
<td>3.17</td>
</tr>
</tbody>
</table>

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

Hypotheses 15 to 18 investigated the differences of learning outcomes of post-test and final-test in each group. The main goal was to find out which learning
Instructional design is the best for cognitive load reduction in short term memory. The research question 2 can be based on the following hypotheses:

**Hypothesis 15:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of traditional instructions delivered without EL (group A). \( H_{15} : \mu_{\text{final-test}} = \mu_{\text{post-test}} \)

The results showed the comparison of the mean score of the final-test \( (M = 16.83, SD = 2.97) \) and the post-test \( (M= 18.28, SD = 2.14) \) of group A. The average score of the final-test of was significantly lower than the post-test score with statistically value of 0.00. In conclusion, hypothesis 15 was rejected.

**Hypothesis 16:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of traditional instructions delivered with EL (group B). \( H_{16} : \mu_{\text{final-test}} = \mu_{\text{post-test}} \)

The results showed the comparison of the mean score of the final-test \( (M = 17.89, SD = 2.67) \) and the post-test \( (M= 21.02, SD = 2.39) \) of group B. The average score of the final-test of was significantly lower than the post-test score with statistically value of 0.00. In conclusion, hypothesis 16 was rejected.

**Hypothesis 17:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of multimedia instructions delivered with EL (group C). \( H_{17} : \mu_{\text{final-test}} = \mu_{\text{post-test}} \)

The results showed the comparison of the mean score of the final-test \( (M = 19.96, SD = 2.42) \) and the post-test \( (M= 24.06, SD = 2.00) \) of group C. The average
score of the final-test of was significantly lower than the post-test score with statistically value of 0.00. In conclusion, hypothesis 17 was rejected.

**Hypothesis 18:** There will be no significant difference between the mean score of the final-test and the mean score of the post-test of 3D based video instructions delivered with EL (group D). \((H_{18} : \mu_{\text{final-test}} = \mu_{\text{post-test}})\)

The results showed the comparison of the mean score of the final-test \((M = 20.96, SD = 3.17)\) and the post-test \((M = 23.41, SD = 2.18)\) of group D. The average score of the final-test of was significantly lower than the post-test score with statistically value of 0.00. In conclusion, hypothesis 18 was rejected.

Using multiple channels can increase the amount of information that the brain can process [Sweller, Van Merrienboer and Paas 1998]. But, too much information delivered in an ineffective manner also can interfere with the brain’s ability to successfully integrate information into long term memory [Sweller 2011; Sweller, Van Merrienboer and Paas 1998]. Therefore, hypotheses 19 to 24 attempted to investigate the effectiveness of learning instructions designed for learning traffic rules.

**Table 6.12:** Results of the Independent Samples T-Test for hypotheses 19 to 24

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Levene’s Test for Equality of Variances</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>(H_{19} : \mu_{\text{post-testC}} = \mu_{\text{post-testB}})</td>
<td>1.43</td>
<td>.03</td>
<td>-10.25</td>
<td>220</td>
</tr>
<tr>
<td>(H_{20} : \mu_{\text{post-testD}} = \mu_{\text{post-testB}})</td>
<td>1.20</td>
<td>.16</td>
<td>-8.04</td>
<td>233</td>
</tr>
<tr>
<td>(H_{21} : \mu_{\text{post-testD}} = \mu_{\text{post-testC}})</td>
<td>1.19</td>
<td>.18</td>
<td>2.32</td>
<td>227</td>
</tr>
<tr>
<td>(H_{22} : \mu_{\text{final-testC}} = \mu_{\text{final-testB}})</td>
<td>1.22</td>
<td>.15</td>
<td>-5.26</td>
<td>220</td>
</tr>
<tr>
<td>(H_{23} : \mu_{\text{final-testD}} = \mu_{\text{final-testB}})</td>
<td>1.42</td>
<td>.03</td>
<td>-7.99</td>
<td>233</td>
</tr>
<tr>
<td>(H_{24} : \mu_{\text{final-testD}} = \mu_{\text{final-testC}})</td>
<td>1.72</td>
<td>.002</td>
<td>-3.36</td>
<td>227</td>
</tr>
</tbody>
</table>

Level of significance \(\alpha = 0.05\) (5% error)
The hypotheses focused on short term memory or working memory by measuring the post-test scores. The results of hypotheses 19 to 24 are indentified in Tables 6.9 and 6.12, and the details of these hypotheses were:

**Hypothesis 19:** There will be no significant difference between the mean score of the post-test of multimedia instructions delivered with EL (group C) and the mean score of the post-test of traditional instructions delivered with EL (group B). \( H_{19} : \mu_{\text{post-testC}} = \mu_{\text{post-testB}} \)

The result showed that there were statistically significant difference in the post-test score between group B (M = 21.02, SD = 2.39) and group C (M=24.06, SD = 2.00) with statistically value of 0.00. The average score of the post-test of group C was significantly higher than the post-test of group B. In conclusion, hypothesis 19 was rejected.

**Hypothesis 20:** There will be no significant difference between the mean score of the post-test of 3D based video instructions delivered with EL (group D) and the mean score of the post-test of traditional instructions delivered with EL (group B). \( H_{20} : \mu_{\text{post-testD}} = \mu_{\text{post-testB}} \)

The result showed that there were statistically significant difference in the post-test score between group B (M = 21.02, SD = 2.39) and group D (M= 23.41, SD = 2.18) with statistically value of 0.00. The average score of the post-test of group D was significantly higher than the post-test of group B. In conclusion, hypothesis 20 was rejected.
**Hypothesis 21**: There will be no significant difference between the mean score of the post-test of 3D based video instructions delivered with EL (group D) and the mean score of the post-test of multimedia instructions delivered with EL (group C). \( (H_{21} : \mu_{\text{post-testD}} = \mu_{\text{post-testC}}) \)

The result showed that there were statistically significant difference in the post-test score between group C (M=24.06, SD = 2.00) and group D (M= 23.41, SD = 2.18) with statistically value of 0.021. The average score of the post-test of group C was significantly higher than the post-test of group D. In conclusion, hypothesis 21 was rejected.

In conclusion, a one-way ANOVA approach was used in order to analyze the mean post-test scores for all of the groups. The \( p\)-value of 0.00 indicates the fact that there were significantly differences between the post-test of all experimental groups. Therefore, the mean score of the post-test of group C (in hypotheses 19 to 21) was the highest \( (\text{Mean}_{\text{post-testC}} = 24.06) \). This shows that the multimedia instruction delivered with EL has the most effective impact on cognitive load reduction in short term memory. However, the mean score of the post-test of 3D based video instruction \( (\text{Mean}_{\text{post-testD}} = 23.41) \) was higher than the mean score of the post-test of traditional instructions delivered with and without EL. Therefore, 3D based video instructions also affected cognitive load reduction in short term memory.

If information does not find its way into long term memory, it is lost [Sweller 2011]. Next, the final-test scores were measured for analyzing the long term memory of learners. The learning instructions were investigated in hypotheses 22 to 24 on the
effectiveness of learning instructions designed for learning traffic rules. The details of hypotheses 22 to 24 were shown as follow:

**Hypothesis 22:** There will be no significant difference between the mean score of the final-test of multimedia instructions delivered with EL (group C) and the mean score of the final-test of traditional instructions delivered with EL (group B). ($H_{22} : \mu_{\text{final-testC}} = \mu_{\text{final-testB}}$)

The result showed that there were statistically significant difference in the average final-test score between group C ($M=19.69$, $SD = 2.42$) and group B ($M= 17.89$, $SD = 2.67$) with statistically value of 0.00. The average score of the final-test of group C was significantly higher than the final-test of group B. In conclusion, hypothesis 22 was rejected.

**Hypothesis 23:** There will be no significant difference between the mean score of the final-test of 3D based video instructions delivered with EL (group D) and the mean score of the final-test of traditional instructions delivered with EL (group B). ($H_{23} : \mu_{\text{final-testD}} = \mu_{\text{final-testB}}$)

The result showed that there were statistically significant difference in the final-test score between group B ($M= 17.89$, $SD = 2.67$) and group D ($M= 20.96$, $SD = 3.17$) with statistically value of 0.00. The average score of the final-test of group D was significantly higher than the final-test of group B. In conclusion, hypothesis 23 was rejected.

**Hypothesis 24:** There will be no significant difference between the mean score of the final-test of 3D based video instructions delivered with EL (group D) and the mean
The result showed that there were statistically significant difference in the final-test score between group C (M=19.69, SD = 2.42) and group D (M= 20.96, SD = 3.17) with statistically value of 0.001. The average score of the final-test of group D was significantly higher than the final-test of group C. In conclusion, hypothesis 24 was rejected.

As a result, hypotheses 22 to 24 were rejected with a level of significance α = .05 (see table 6.12). The mean score of the final-test of 3D based video instruction delivered with EL (Mean_{final-testD} = 20.96) was the highest as showed in Table 6.9. Consequently, 3D based video instruction delivered with EL has the most effective impact on reducing the cognitive load significantly in long term memory. Also, multimedia instruction delivered with EL (Mean_{final-testC} = 19.69) affected cognitive load reduction in long term memory with a higher score of the final-test than traditional instructions delivered with and without EL as well. The p-value of 0.00 which was analyzed using a one-way ANOVA indicates the fact that there were significantly differences between the final-test of all experimental groups.

### 6.4.3 Testing hypotheses 25 to 30

Based on Research Question Three, learner satisfaction towards the learning instructions can positively affect the effectiveness of learning outcomes, and it can provide the instructors or teachers to design effective learning materials. Therefore, attitude on learning instructions was investigated in order to examine the learners’ perception towards the effectiveness of VEL framework. Table 6.13 reports the results
analyzed from five Likert scale and Table 6.14 presents the summary of the mean scores of learner satisfactions which were analyzed using the Independent Samples T-Test.

**Table 6.13:** Mean score of learner satisfactions

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>3.30</td>
<td>0.20</td>
<td>4.29</td>
<td>0.13</td>
</tr>
</tbody>
</table>

**Table 6.14:** Learner satisfaction results

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Levene’s Test for Equality of Variances</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂₅: μ₈ = μ₆</td>
<td>1.35</td>
<td>.06</td>
<td>-50.15</td>
<td>213</td>
</tr>
<tr>
<td>H₂₆: μ₆ = μ₆</td>
<td>1.17</td>
<td>.21</td>
<td>-67.84</td>
<td>207</td>
</tr>
<tr>
<td>H₂₇: μ₈ = μ₆</td>
<td>1.05</td>
<td>.40</td>
<td>-65.36</td>
<td>220</td>
</tr>
<tr>
<td>H₂₈: μ₈ = μ₆</td>
<td>1.58</td>
<td>.01</td>
<td>-11.16</td>
<td>220</td>
</tr>
<tr>
<td>H₂₉: μ₉ = μ₆</td>
<td>1.42</td>
<td>.03</td>
<td>-8.79</td>
<td>233</td>
</tr>
<tr>
<td>H₃₀: μ₉ = μ₆</td>
<td>1.11</td>
<td>.29</td>
<td>2.76</td>
<td>227</td>
</tr>
</tbody>
</table>

Level of significance α = 0.05 (5% error)

Research Question Three can be based on the following hypotheses 25 to 30 which were:

**Hypothesis 25:** There will be no significant difference between the mean score of the learner satisfaction on traditional instructions delivered with Experiential Learning (group B) and the mean score of learner satisfaction on traditional instructions delivered without Experiential Learning (group A). (H₂₅: μ₈ = μ₆)

The results showed the comparison of the mean score of the mean score of the learner satisfaction on group B (M = 4.29, SD = 0.13) and the mean score of the learner
satisfaction on group A (M= 3.30, SD = 0.20). The average score of group B was significantly higher than group A with statistically value of 0.00. In conclusion, hypothesis 25 was rejected.

**Hypothesis 26**: There will be no significant difference between the mean score of the learner satisfaction on multimedia instructions delivered with Experiential Learning (group C) and the mean score of learner satisfaction on traditional instructions delivered without Experiential Learning (group A). (\(H_{26}: \mu_C = \mu_A\))

The results showed the comparison of the mean score of the learner satisfaction on group C (M = 4.50, SD = 0.10) and the mean score of the learner satisfaction on group A (M= 3.30, SD = 0.20). The average score of group C was significantly higher than group A with statistically value of 0.00. In conclusion, hypothesis 26 was rejected.

**Hypothesis 27**: There will be no significant difference between the mean score of the learner satisfaction on 3D based video instructions delivered with Experiential Learning (group D) and the mean score of the learner satisfaction on traditional instructions delivered without Experiential Learning (group A). (\(H_{27}: \mu_D = \mu_A\))

The results showed the comparison of the mean score of the learner satisfaction on group D (M = 4.45, SD = 0.08) and the mean score of the learner satisfaction on group A (M= 3.30, SD = 0.20). The average score of group D was significantly higher than group A with statistically value of 0.00. In conclusion, hypothesis 27 was rejected.

**Hypothesis 28**: There will be no significant difference between the mean score of the learner satisfaction on multimedia instructions delivered with Experiential Learning
(group C) and the mean score of the learner satisfaction on traditional instructions delivered with Experiential Learning (group B). \( (H_{28}: \mu_C = \mu_B) \)

The results showed the comparison of the mean score of the mean score of the learner satisfaction on group C \( (M = 4.50, SD = 0.10) \) and the mean score of the learner satisfaction on group B \( (M = 4.29, SD = 0.13) \). The average score of group C was significantly higher than group B with statistically value of 0.00. In conclusion, hypothesis 28 was rejected.

**Hypothesis 29:** There will be no significant difference between the mean score of the learner satisfaction on 3D based video instructions delivered with Experiential Learning (group D) and the mean score of the learner satisfaction on traditional instructions delivered with Experiential Learning (group B). \( (H_{29}: \mu_D = \mu_B) \)

The results showed the comparison of the mean score of the mean score of the learner satisfaction on group D \( (M = 4.45, SD = 0.08) \) and the mean score of the learner satisfaction on group B \( (M = 4.29, SD = 0.13) \). The average score of group D was significantly higher than group B with statistically value of 0.00. In conclusion, hypothesis 29 was rejected.

**Hypothesis 30:** There will be no significant difference between the mean score of the learner satisfaction on 3D based video instructions delivered with Experiential Learning (group D) and the mean score of the learner satisfaction on multimedia instructions delivered with Experiential Learning (group C). \( (H_{30}: \mu_D = \mu_C) \)

The results showed the comparison of the mean score of the mean score of the learner satisfaction on group D \( (M = 4.45, SD = 0.08) \) and the mean score of the learner
satisfaction on group C (M = 4.50, SD = 0.10). The average score of group D was significantly higher than group C with statistically value of 0.006. In conclusion, hypothesis 30 was rejected.

In order to analyze the mean satisfaction scores for all of the groups, a one-way ANOVA approach was used. The p-value of 0.00 shows that there were significant differences between the satisfaction scores of all the experimental groups. The results also showed that the mean scores of group C was the significantly highest on user satisfaction. Moreover, the relationship between learner satisfaction and the tests was analyzed by using Pearson's Correlation Coefficients for this research. In statistics, the correlation coefficient \( r \) measures the strength and direction of a linear relationship between two variables. The value of \( r \) is always between +1 and −1. A coefficient of +1 indicates a perfect positive correlation. A coefficient of -1 indicates a perfect negative correlation whereas a coefficient of zero indicates there is no discernable relationship between fluctuations of the variables [Nagelkerke 1991]. Positive values indicate a relationship between \( x \) and \( y \) variables such that as values for \( x \) increase, values for \( y \) also increase. Negative values indicate a relationship between \( x \) and \( y \) such that as values for \( x \) increase, values for \( y \) decrease [Hinkle et al. 1998]. Interpretation of the \( r \) values is shown in Table 6.15 [Hinkle, Wiersma and Jurs 1998]:

---

121
Table 6.15: Correlation coefficient interpretation guidelines

<table>
<thead>
<tr>
<th>Correlation Coefficient (r)</th>
<th>Strength of the relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>A perfect (negative) linear relationship</td>
</tr>
<tr>
<td>-0.7</td>
<td>A strong (negative) linear relationship</td>
</tr>
<tr>
<td>-0.5</td>
<td>A moderate (negative) relationship</td>
</tr>
<tr>
<td>-0.3</td>
<td>A weak (negative) linear relationship</td>
</tr>
<tr>
<td>0</td>
<td>No linear relationship</td>
</tr>
<tr>
<td>0.3</td>
<td>A weak (positive) linear relationship</td>
</tr>
<tr>
<td>0.5</td>
<td>A moderate (positive) linear relationship</td>
</tr>
<tr>
<td>0.7</td>
<td>A strong (positive) linear relationship</td>
</tr>
<tr>
<td>1</td>
<td>A perfect (positive) linear relationship</td>
</tr>
</tbody>
</table>

Table 6.16: Results of Pearson’s correlation coefficients

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test</td>
<td>0.130</td>
<td>-0.036</td>
<td>-0.025</td>
<td>-0.201</td>
</tr>
<tr>
<td>Final-test</td>
<td>0.063</td>
<td>0.101</td>
<td>-0.003</td>
<td>-0.015</td>
</tr>
</tbody>
</table>

From Table 6.16, the relationship between satisfaction and the post-test of group B indicated a weak negative linear relationship, $r$ values was -0.036. But the final-test indicated a weak positive linear relationship which $r$ values was 0.101. Then, the results of Group C and D indicated weak negative linear relationship between satisfaction and the tests of both post-tests and final-tests (see Table 6.16). The results showed the relationships between satisfactions and both post-tests and final-tests of all experiment groups had a weak linear correlation, $r$ value of close to 0.

6.5 Summary

This chapter describes the consequences of the two previously discussed sections. First is the consequence of the validity and reliability testing on the learning
instructions through two sets of questions. The finding indicates that the learning instructions and two sets of questions were in the acceptable range of values from the analysis criteria.

Second is the results obtained from the hypotheses testing in this study. The hypotheses clearly approve the positive impact of applying the EL on the learning instructions. In addition, the finding shows the effectiveness of the VEL framework applied for the learning instructions on short term and long term memory referring to the CLR. Moreover, finding also shows learner satisfaction towards learning instructions of the VEL purposed in this study. All results were achieved through a number of statistical testing techniques which included: mean, standard deviation, independent samples t-test, pair samples t-test, and internal consistency reliability testing. Finally, the developed null hypotheses were rejected with difference significancy value at 0.05.

Discussion of the findings and conclusions of this study are given in the final chapter.
Chapter 7

Discussion and Conclusions

The results of all the questionnaires and data analysis have been reported in the previous chapter. In this thesis, all results were used to verify their support for the research hypotheses and to provide answers to the research questions. Moreover, this chapter presents a summary of the research findings and discussions on the VEL framework and the cognitive load reduction system. Finally, this chapter provides a summary of completed work in this thesis, limitations, and directions for future work.

7.1 Summary of Research Findings

The purpose of this study was to examine the effectiveness of the VEL framework aiming to reduce cognitive load on learning traffic rules for Thai undergraduate students. The VEL framework was developed in order to minimize extraneous load in the learning process by using the theories of multimedia based learning. An online learning system was developed that delivered the content of traffic rules to the participants. To examine the effect of the VEL framework, the proposed distance learning system was created. It represented the same topics and contents to the participants in three different image versions. The three were representation of text narration including static images, 2D animation pictures, and 3D based videos. Three treatment groups and one control group were used to establish the effect of the VEL framework. These were traditional instructions delivered without EL, traditional instructions delivered with EL (static images), multimedia instructions delivered with EL (2D animation images), and 3D based video instructions delivered with EL. To
determine the effects of these learning instructions as presented, this study comprises three research questions:

1. **Does Experiential Learning affect cognitive load reduction on learning of traffic rules by Thai undergraduate students?**

   The first test investigated the effect of learning instructions delivered with EL for educating traffic rules. The aim was to determine the performance of EL techniques which were designed to enhance the learning process. The results indicated that EL can decrease cognitive load on learning of traffic rules. According to the results of hypotheses 1 to 14, the findings show that participants can gain more learning experiences from the given examples, practices, and sub-tests in each topic, as well as improved their knowledge after learning. The participants could apply the previously provided information and they were able to answer questions from the post-test and final-test. The mean scores of the post-test and final-test were higher than the mean scores of the pre-test. This demonstrated that the learners had improved their knowledge from learning instructions delivered with EL (group B, C, D), and the approach also reduced cognitive load in short term memory while storing the information in the long term memory.

   In the beginning, the hypotheses 1 to 4 investigated the comparision on the average score of pre-test and post-test in each group. The results showed that the average score of all experimental groups from the post-test were significantly higher than the average score of all experimental groups from the pre-test. These results indicated that all learning instructions can efficiently be used to enhance the knowledge on traffic rules.
Furthermore, this study continued to investigate the effect of learning instructions for integrating the information with long term memory. The results of hypotheses 5 to 8 were investigated the comparision of the pre-test and the final-test score in each group. The results showed that the average scores of the final-test of all groups were significantly higher than the pre-test score of all groups. These results showed that all learning instructions can efficiently be used to enhance the knowledge on traffic rules and information can be stored in long term memory.

In addition, the results of hypotheses 9 to 11 identified the analysis of performance of learning instructions delivered with EL techniques. These hypotheses were created to investigate the differences in mean scores, the mean score of the post-test of learning instructions delivered with EL (group B, C and D) and learning instructions delivered without EL (group A). Summarily, the mean post-test score of learning instructions delivered with EL were higher than the mean pre-test score of the learning instructions delivered without EL. This shows that the EL has substantial influence on cognitive road reduction and it can efficiently be used to enhance the knowledge on traffic rules in short term memory.

Two weeks later, the participants were asked to complete the final-test after completing the post-test. This test aimed to investigate any decrease of cognitive load in long term memory by examining the hypotheses 12 to 14, which illustrate a performance assessment approach of learning instructions delivered with EL. The mean final-test score of learning instructions delivered with EL were higher than the mean pre-test score of the learning instructions delivered without EL. Therefore, the EL has substantial influence on cognitive road reduction and it can efficiently be used to enhance the knowledge on traffic rules in long term memory.
2 Are there any differences in learning outcomes (cognitive load reduction) for learners between traditional learning instructions, multimedia instructions (2D animations), and 3D based video instructions on educating Thai undergraduate students on traffic rules?

The VEL framework was designed using different multimedia tools which were using traditional learning instructions (group B), multimedia instructions (group C), and 3D based video instructions (group D). The aim of the second research question was to examine the effectiveness of these learning instructions in decreasing cognitive load by measuring the learning outcomes. The results described that the VEL framework can reduce cognitive load, and multimedia instructions designed with EL and 3D based video instructions designed with EL can affect in learning on educating traffic rules for Thai undergraduate students. These results can be illustrated in the testing of hypotheses 15 to 24 which were designed in order to answer this research question.

The hypotheses 15 to 18 investigated the mean post-test score and the mean final-test score in each experimental group. From group A to D, the results show the mean post-test score were significantly higher than the mean final-test score. It shows that the learning instructions designed for this study can effectively improve academic performance of learners which optimize the information contained in short term memory more than long term memory.

Next, the hypotheses 19 to 21 tested the learning instructions designed with EL technique focusing on short term memory or working memory by measuring the average post-test scores between treatment groups. The results shows that the
average post-test score presented from the highest to lowest were multimedia instruction delivered with EL (group C; M=24.06, SD=2.00), 3D based video instructions delivered with EL (group D; M=23.41, SD=2.18), and traditional instruction delivered with EL (group B; M=21.02, SD=2.39), respectively. From this result, multimedia instruction delivered with EL (group C) provides the best performance media to reduce cognitive load in short term memory (group C>D>B).

Then, the hypotheses 22 to 24 investigated the learning instructions designed with EL technique focusing on cognitive load reduction in long term memory by measuring the average final-test scores. In general, long term memory is where what learners know is stored and where learners integrate new information [Mayer and Mereno 2003]. If information does not find its way into long term memory, it can be lost. The average final-test scores presented from the highest to lowest were 3D based video instructions delivered with EL (group D; M=20.96, SD=3.17), multimedia instruction delivered with EL (group C; M=19.69, SD=2.42), and traditional instruction delivered with EL (group B; M=17.89, SD=2.67). Consequently, 3D based video instructions delivered with EL (group D) provides the best performance media to reduce cognitive load in long term memory (group D>C>B). From these results, the VEL framework designed for learning instructions in this study can improve the awareness, knowledge, and skills for learners.

Mayer (2005) and his colleagues also researched that narration and video is much more effective than narration and text. Similarly, narration and video appear to be more effective than narration, video and text [Mayer 2005]. The results from the hypotheses 15 to 24 illustrated that the VEL framework can reduce cognitive load for
learners, and multimedia instructions designed with EL and 3D based video instructions designed with EL are more likely to be effective in learning on educating traffic rules for Thai undergraduate students.

3 Does satisfaction on learning instructions have an influence on learning outcomes (cognitive load reduction) on learning of traffic rules by Thai undergraduate students?

In the third research question, this study investigated learner satisfaction on learning instructions that may effect on cognitive load for learning traffic rules. Interface-induced user satisfaction may become increasingly prominent when multiple visual properties are included in the design [Hu et al. 1999]. Therefore, the use of graphical interfaces with text narrations may result in a higher level of learner satisfaction than only text narrations.

This study developed the learning instructions with the presentation of content among the animation, audio and the text narration. Learner satisfaction was investigated on these designed learning instructions. Figure 6.1 describes the results of this research question that learner satisfaction has an influence on learner accomplishments and learning outcomes positively for learning of traffic rules by Thai undergraduate students. The research question three investigated the results of hypotheses 25 to 30 in order to analyze the learner satisfaction on learning instructions. The participants were required to complete the questionnaires of satisfaction testing after completing the first post-test. The results are shown in Figure 6.1. The mean score of the learner satisfaction on learning with multimedia instruction delivered with EL (group C) was the highest (M=4.50, SD=0.10). Then, the mean scores of the learner
satisfaction on 3D based video instructions delivered with EL (group D, M=4.45, SD=0.08), and traditional instruction delivered with EL (group B, M=4.29, SD=0.13) were lower than group C. The mean score of the learner satisfaction on the traditional instruction delivered without EL was the lowest value. Consequently, it shows that the multimedia instruction delivered with EL provides the greatest factor influencing learner satisfaction with learning instructional design (C>D>B>A).

Satisfaction refers to a range of feelings, from positive to negative, about a learning performance [Bradford 2011]. Cognitive load may affect users’ general satisfaction and performance when completing complex tasks [Bradford 2011]. As the results, the treatment groups of learning that showed the higher average values of satisfaction has an influence on the higher average score of learning outcomes as well. Therefore, satisfaction on learning instructions also has an influence on learning outcomes (cognitive load reduction) for learning of traffic rules by Thai undergraduate students. Although, the results indicated that the relationships between satisfactions and both post-tests and final-tests of all experiment groups had weak linear correlation.
7.2 Discussion

7.2.1 Efficiency of the VEL framework

This section discusses the study of the efficiency of the VEL framework comprising EL techniques and multimedia based learning on traffic rules. Drivers must have the necessary skills and knowledge of traffic rules to properly and safely drive a motor vehicle. They should have the knowledge and the ability to safely operate their vehicles permanently. Efficiency of the VEL framework is described below:

- Using EL technique in the learning instructions designed for this study can help learners to repeat and rethink in order to organize the working memory with the brain’s ability to successfully integrate information into long term memory. This helps new information to be stored and integrated into long term memory and to improve learner’s knowledge on traffic rules as well as applying the knowledge for driving in practical situations. Learning and knowing are intimately linked to real-life situations. Learning is the process in which knowledge is created through the transformation of experience [Klob 1984]. Experiential Learning (EL) is usually associated with a constructivist approach, which argues that humans construct meaning from current knowledge structures [Kolb, Boyatzis and Mainemelis 2000]. EL and real-life learning are mutually supportive and can provide significant benefit for learning and applying knowledge of traffic rules in real-life driving situations. Consequently, this study found that learning instructions
delivered with EL can significantly affect learning of the traffic rules much more than learning instructions delivered without EL. Additionally, EL techniques can help learners to handle extensive information the brain can process. This study also found that EL techniques can be a powerful and effective learning tool to increase the effectiveness of learning systems on public education in traffic rules. It has been found that the effectiveness of the learning instructions delivered with EL can improve learning process to the learners.

The representation of information in both the auditory and visual channels of VEL framework can improve better learning process and knowledge. The VEL framework had been developed and represented different image’s styles with text narration and audio on each treatment groups. Learning instructions using different multimedia tools used traditional learning instructions (static images), multimedia instructions (2D animations), and 3D based video instructions. Nowadays, using graphics in learning process has become a popular tool to facilitate comprehension, learning, memory, communication and inference [Tversky et al. 2002]. The use of 3D animation gives a better insight on some difficult techniques in learning memory management concepts, especially when the static pictures in the book could not help learners to visualize and grasp some important concepts [Rias and Zaman 2009]. The testing results found the same that the static pictures showed the lower average scores than the others and the results of this study also drawn the same conclusion.
7.2.2 Effect of multimedia instructions on cognitive load reduction

This study aimed to reduce cognitive load on educating traffic rules for undergraduate students in Thailand. The VEL framework was created and developed based on Information Processing Model based on Mayer (2005). According to the cognitive load theory, short term memory (working memory) is very limited that can only handle small amounts of information before it has to be integrated into long term memory or lost [Sweller 2011]. Many studies in the past have shown that presenting information in a way that makes use of existing organizing structures (schema) enabling to help learners organize the information efficiently [Baddeley 1999]. This can greatly assist the learner in incorporating information into long term memory. Long term memory holds a permanent and massive body of knowledge and skills [Shaffer et al. 2003]. The use of VEL framework is discussed on the effect of multimedia instructions on cognitive load reduction as followed:

- The use of graphics in learning instructions including audio and text narration can be an effective way to reduce the extraneous cognitive load for learners. The VEL framework was created and developed according to the effectiveness of multimedia based learning. The results show that the VEL framework can improve learners' learning skills and experiences. They finally gain more knowledge and skills. Mayer (2005) said that brain processing is relevant to multimedia learning. Effective multimedia recognizes that working memory has a limited capacity to
process information. Thus, effective multimedia presentations take advantage of both the auditory and visual channels in working memory to deliver the content [Mayer and Johnson 2008]. Using multiple channels increases the overall amount of information the brain can process [Sweller 2011]. This helped to reduce cognitive load in short term memory, and greatly help the learner in incorporating information into long term memory. Therefore, the VEL framework can provide the efficiency for reduce cognitive load in learning traffic rules. Thereby, the VEL framework can improve the learning process more effectively.

This study found that there were statistically significant difference among the learning outcomes of representing lessons with static pictures (Group B), 2D animations (Group C) and 3D based videos (Group D). In the first post-test, representing 2D animations of learning instruction had a significant impact on the increase in learning in short term memory (see Figure 6.1). Accordingly, the results of this research were anticipated that applying 2D animations in learning process can help to eliminate extraneous visual information in short term and can be stored into long term memory consistently. John Sweller (1988) illustrated that information from working memory must successfully make its way to long term memory. Some researchers have explained that learning systems using dynamic representing such as animations video, or the combination of speech and pictures with the positive testing results. For example, the use of video in multimedia learning environments was examined on a computer-based multimedia
presentation, cognitive load were assessed [Homer et al. 2008; Kalyuga 2008; Moreno 2007; Wong et al. 2009]. In contrast, the results of the final-test showed that the average scores of the learning instructions with 2D animations were lower than the average scores of the learning instructions with 3D based video (see Figure 6.1). Thus, learning with 2D animation is more likely to be effective for improving knowledge and skills in short term memory. The use of VEL framework for traffic rules education proposes in this study has been proved that it can help learners to gain a better knowledge and skills and reduce cognitive load in short term memory rather than long term memory.

Learning with 2D animations combined with text narration and audio can help learners to increase the amount of information that the brain can process. However, this research found that using 3D based video in the learning instruction can contribute to reduce cognitive load in learning in long term memory. Learners perceived visualizations in real environments from 3D based video better than 2D animations. From this aspect, learner may be able to be made aware of the real traffic situations which helped learner to recall rather than just remember the lessons. Effortless learning environment helped learners store the knowledge acquired in their long term memories, and at the same time effectively improved the learning results with a reduced cognitive load [Hsiung and Lai 2013]. Beside, learner may utilize favorably their own experience from daily traffic environments to enhance new information. More recently, cognitive load theorists have shifted their attention to
how learner characteristics, such as prior knowledge and motivational beliefs, interact with instructional designs to influence the effectiveness of CLT methods [Moreno 2006]. According to the CLT, the effectiveness of certain instructional techniques depends, in part, on the learner’s experience [Artino Jr 2008].

### 7.2.3 Effect of learner satisfaction on cognitive load reduction

The effect of learner satisfaction in the virtual learning process provided for this study is discussed in this section. Learner satisfaction criteria used for this investigation were perceived usefulness, perceived ease of use, perceived value, and perceived system quality to measure learner satisfaction [Chiu, Hsu, Sun, Lin and Sun 2005]. The result of a measurement represented the capacity of the proposed system on educating road traffic in Thailand which influenced user’s learning continuance intention of undergraduate students. The participants were requested to complete the questionnaires of learner satisfaction after finishing the first post-test. Interestingly, Figure 6.1 showed the results of comparison of mean scores between learner satisfaction and the tests (pre-test, post-test, and final-test). Figure 6.1 showed that the satisfaction’s scores of the learning instruction using 2D animations were the highest average scores in this study. In the post-test, this research explored that the use of 2D animation combined with text narration and audio can provide the better average scores of learning outcomes as well. In the meantime, using 3D based videos in learning process indicated the lower average scores of satisfaction and learning outcomes than using 2D animations. This study reveals that learner satisfaction is a significant effect of learning outcomes. It shows a direct effect on user satisfaction. This relationship can
use learner satisfaction as a criterion of system effectiveness [Al-Maskari and Sanderson 2010]. Learning system was significant to influence the learner satisfaction while the usage and learner satisfaction significantly influence the cognitive load reduction.

Then, the analysis on second post-test or final-test explored that the average scores of learning instruction using 3D based videos showed the higher average score than using 2D animations. In contrast, the average scores of learner satisfaction on using 3D based videos were lower than using 2D animation (see Figure 6.1). Again, the results illustrated in the opposite way. There may be a question why the post-test and the final-test showed contradictory results. Clearly, understanding the factors influencing learner satisfaction with online courses is a critical issue for researchers and practitioners alike [Isik 2008]. To investigate use learner satisfaction on the VEL framework, this study should concern some necessary factors that affect the learner satisfaction in an online learning system. Furthermore, applying image's styles in learning process may be considered as an important factor on individual learning behavior as mentioned in the previous section. This is because the results were indicated from the average scores of all used criteria for this research summarizing the investigation that contribute to web-based learning systems. There are other factors that may affect learner satisfaction for e-learning systems and their relationships should be investigated.
7.3 Limitations

There are several limitations that may have restricted the probability of generalizing the findings of this study.

- *Learning styles*: According to the research results, this study discovers that using different image styles as a tool for learning process can affect learners’ experience of cognitive load in short term and long term memory. From this finding, a specific type of visualization or image styles for effective learning should be concerned with other factors such as individual experience, computer skills, etc. As with any instructional tool, multimedia may work better for some students than others. There is a growing body of research showing that students learn in different ways and that information should be presented in different ways to engage students with differing learning styles [Austin 2009]. So, different learning styles may arouse different attitudes, perceptions and results.

- *Knowledge background*: knowledge backgrounds of students from different majors could influence how they use and think about learning with computer based technologies. Presented with a highly complex construct could lead to different results. Learners who have knowledge background in computer skills may get better results in learning.

- *Materials for data collection*: For collecting data of group D (3D based videos), materials for data collection such as Internet speed in University, limited time on allowing of using computer laboratory could be possibly factors that affect to the research results. From the results of satisfaction, it was shown that the average scores of group D (3D based videos) were lower than group C (2D animation) and limitation in the delivery resources could be the contributing factor.
7.4 Recommendation for Future Research

Following the previous discussion, further research and system development is needed to maintain the VEL framework and to increase knowledge, skills, and understanding concerning traffic rules in Thailand. Some of the issues and directions for future work are described as follow.

1. Utilization and development of advanced technologies

The use of many different media formats, such as sound, animation, text, static images, video, virtual reality, and various combinations of these, has become widespread in education. Such technologies have also advanced at a rapid pace since the beginning of this study. Possibilities for future research using other means of advanced multimedia technologies to learning in traffic rules and situations should be considered. Computer based multimedia material offers different means of supporting animations, videos, and 3D information representations. Advanced technology in computer based multimedia to learning can provide high performance on specific types of visualization. Accordingly, graphics hardware and technologies are rapidly evolving and the increased Internet connection speed allows the sharing of large amounts of data and information among geographically distributed users. The development of networked graphic applications is still complicated and requires expert knowledge. Although some collaborative graphic technologies and applications have already been developed, most of them are particularly concerned with offering a high level realistic representation of the virtual world in traffic environments. Using 3D based videos offers opportunity to improve learners’ knowledge and provide learners with richer experiences in real environments on traffic rules, and this needs advanced technologies to develop graphic...
applications. Additionally, the use of multimedia and video in teaching and learning has been increasing during the last two decades. Educational video is one specific multimedia type that has been described as important in helping students to acquire knowledge due to its capability to present learning content dynamically and the use of multiple representations, such as still and moving images, audio, and animations [Chandler 2009].

2. Means to achieve a high learning performance on using the VEL Framework

The VEL framework developed in this study can improve user performance by reducing cognitive load of learners during the learning process. Therefore, the VEL framework can be used to improve learning on educating in other topics and also applied to different age groups. The most recent development in multimedia technology has the potential to overwhelm the apparently limited resources of the human brain. It is important to seriously consider cognitive research and look for ways to apply it more effectively. The growth in computer based training will precipitate increasing demand for effective learning design in multimedia instruction. Various features that facilitate learner interaction and learning processes closely to real life environments, such as the opportunity to make use of video or audio files, and voice chat make virtual worlds particular interesting applications for educators.

7.5 Conclusion

Road traffic education has a significant effect on the drivers, as stated by the Department of Land Transport in Thailand. A reduction in the number of crashes or injuries resulting from a crash might be considered the main outcome for measuring the
effectiveness of a road safety education program. A VEL framework was proposed to improve the learning process aiming to reduce cognitive load in learning. This study developed the VEL framework based on the Mayer’s model which utilized multimedia to learning and EL designed for educating traffic rules for Thai undergraduate students in Thailand. This contributed to knowledge concerning instructional designs and provided a better understanding of the use of various educational technologies in order to educate Thai undergraduate students on traffic rules with an aim to reduce traffic accidents. This study will also contribute towards a better understanding on how to improve the education of traffic rules using EL Techniques. The results examined the mean scores of the pre-test, post-test, and final-test.

This study had four different instructional designs but presented the same contents. The control group (group A) was traditional instructional design comprised text and pictures. Three experimental groups which were traditional instructional design with EL comprised narration of text, and pictures (group B), multimedia instructional design with EL comprised narration of text, pictures, sounds, and 2D animations (group C), and 3D based instructional design with EL comprised of narration of text, pictures, sounds, and 3D videos (group D).

The result showed that learning instructions designed with EL was able to support cognitive load reduction in both short term and long term. Using EL technique in the learning instructions designed for this study can help learners to repeat and rethink in order to organize the working memory with the brain’s ability to successfully integrate information into long term memory. This helps new information to be stored and integrated into long term memory and to improve learner’s knowledge on traffic rules as well as applying the knowledge for driving in practical situations.
Moreover, the results showed that the VEL framework which was developed according to the effectiveness of multimedia based learning can improve learner learning skills and experiences. The representation of information in both the auditory and visual channels of VEL framework can improve better learning process and knowledge in this study.

Next, the results also showed that all the learning instructional designs had the capacity to educate the undergraduate students on traffic rules in Thailand. From the results in this study, multimedia instruction delivered with EL (group C) and 3D based video instruction delivered with EL (group D) can improve knowledge on traffic rules for learners. Multimedia instructional designed with EL techniques (group C) can improve learner’s knowledge and affects cognitive load reduction to be the best in short term memory. Also, the study found that 3D based video instruction (group D) affects cognitive load reduction to be the best in long term memory. Then, the effect of learner satisfaction on cognitive load reduction was examined and found that learner satisfaction can effect to learning outcome. However, user satisfaction on the VEL framework may need more learner satisfaction criteria for online learning. Furthermore, people learn in different ways, multimedia based learning may work better for some learners than others. A visual presentation of information as instruction tools should be considered importantly to individual learning behavior.

In addition, this chapter describes the limitations and the directions for future work. There are several limitations that may have restricted the probability of generalizing the findings of this study such as learning styles, knowledge background of each learner, and developing materials for data collection.
For future work, utilization and development of advanced technologies have become an important material to develop the VEL framework such sound, animation, text, static images, video, and virtual reality. In addition, The VEL framework can improve user performance in learning process on educating in other topics and also apply to different age groups. The VEL model can be used to improve education on traffic rules with respect to the aspect that teachers and instructors should take the various learning styles into consideration when developing lesson plans and when instructing the learners as some learners may learn best when they were taught in specific manners, while others may find that the same approach to be confusing and difficult.

It is realized that research work never finishes. While there are other directions that could lead this study to new findings and new knowledge, it is necessary to close this chapter with the humble contributions that have been made. It is hopeful that the present findings will provoke future work and result in reduction of traffic accidents through better education and learning by the Thai undergraduate students on the traffic rules.
References


PEDEN, M., SCURFIELD, R., SLEET, D., MOHAN, D., HYDER, A.A., JARAWAN, E. AND


Appendices
Appendix A: The system design

Appendix A-1: System flow Chart of the learning system

Figure A.1: System Flow Chart
Appendix A-2: Data flow diagram of the learning system

Figure A.2: Data flow diagram
Appendix B: Graphic User Interfaces

Appendix B-1: An example of lesson learned of group A (traditional instructions delivered without EL)

Figure B.1: The interface of lesson learned of group A (control group)
Appendix B-2: An example of lesson learned of group B (traditional instructions delivered with EL)

Figure B.2: The interface of lesson learned of group B
Appendix B-3: An example of lesson learned of group C
(multimedia instructions delivered with EL)

Figure B.3: The interface of lesson learned of group C
Appendix B-4: An example of lesson learned of group D (3D based video instructions delivered with EL)

Figure B.4: The interface of lesson learned of group D
Appendix B-5: An example of 3D videos

Figure B.5: The interface of examples of 3D videos
Appendix B-6: An example of the test questions

Figure B.6: The interface of the test questions
Appendix B-7: An example of the practices

Figure B.7: The interface of the practices
Appendix C: Copies of consent letters

Appendix C-1: English Version of Consent Letter

A Study of the Effectiveness on Virtual Experiential Learning (VEL) for Cognitive Load Reduction on Educating Thai Undergraduate Students on Traffic Rules

Call for Volunteers

Volunteers are needed for a PhD study being conducted through Murdoch University, Australia. The study is looking at aspects of your practices in the use of Experiential Learning for Cognitive Load Reduction on educating Thai Undergraduate Students on traffic rules.

The purpose of this project is to conduct a detailed evaluation of the Cognitive load program that is being run in the website. Associate Professor Dr. Lance Chun Che Fung is working and Ms Sirilak Borirug (PhD student) to evaluate this program. We hope to find whether the program is meeting its aims successfully and whether there is anything we can learn from you that will be of value to other similar programs.

To participate, please read the consent statement and follow the instructions. This study will lead you to the online learning of traffic rules and your information will be kept confidentially.

(Providing two buttons of “next” button to continue the Consent Statement Page and “cancel” button to stop the study)
Appendix C-2: Thai Version of Consent Letter

การศึกษาถึงประสิทธิผลของการใช้ระบบการเรียนรู้ด้วยประสบการณ์เสมือน เพื่อลดภาระทางปัญญาให้กับนักเรียนระดับปริญญาตรีในการศึกษากฎจราจรในประเทศไทย

(A Study of the Effectiveness on Virtual Experiential Learning (VEL) for Cognitive Load Reduction on Educating Thai Undergraduate Students on Traffic Rules)

การวิจัยนี้เป็นส่วนหนึ่งของการศึกษาระดับปริญญาเอกด้านเทคโนโลยีสารสนเทศ ของดิฉัน นางสาวสิริลักษณ์บริรักษ์ ซึ่งมีอาจารย์ที่ปรึกษา การวิจัยคือ รองศาสตราจารย์ ดร.แลนซ์ ฟุง (Associate Professor Dr. Lance Fung)

ลักษณะและวัตถุประสงค์ของการวิจัย

อุบัติเหตุทางถนนเป็นปัญหาหลักของประเทศที่ต้องเร่งแก้ไข ซึ่งสาเหตุส่วนใหญ่เกิดจากกลุ่มวัยรุ่นที่ขาดประสบการณ์และความรู้ในการขับขี่ ดังนั้น การจัดการองค์ความรู้โดยใช้การศึกษาและการนำเสนอข้อมูลที่เป็นประโยชน์ในการขับขี่ให้แก่กลุ่มวัยรุ่นเหล่านี้ โดยคาดหวังเพื่อช่วยลดภาระทางปัญญาที่เกิดขึ้นได้ แต่อย่างไรก็ตาม วิธีการให้ความรู้แก่ผู้เรียนที่มีอยู่ในปัจจุบันอาจไม่ประสบความสำเร็จที่ดีที่ควร อันเนื่องมาจาก การนำเสนอข้อมูลที่มากเกินความจำเป็น ทำให้เกิดปัญหาทางระบบปัญญา ส่งผลถึงความสามารถในการจำโดยตรง

วัตถุประสงค์ในการศึกษา คือการนำเสนอทฤษฎี ตัวอย่างสร้างการเรียนรู้ด้วยมัลติมีเดีย และวีดิโอสามมิติผสมผสานกับการเรียนรู้ด้วยประสบการณ์ จะมีผลต่อการเรียนรู้ ความเข้าใจ และสามารถลดภาระทางปัญญาทางการศึกษากฎจราจร ให้กับวัยรุ่นได้ดียิ่งขึ้น

ประโยชน์ของการวิจัย

การวิจัยนี้จะช่วยให้ผู้เข้าร่วมได้เรียนรู้และศึกษาถึงกฎจราจร ผ่านกระบวนการเรียนรู้เสมือน การวิจัยนี้จะสนับสนุนและช่วยให้เกิดความเข้าใจในทางทฤษฎีการนำระบบการเรียนรู้แบบเสมือนมาใช้เพื่อลดภาระทางปัญญาให้กับผู้เรียนในกฎจราจรและนอกจากนี้จะช่วยให้เข้าใจถึงการออกแบบโครงสร้างระบบการเรียนรู้แบบเสมือนเครื่องขับข่องเครื่องเงินในประเทศไทยอีกด้วย

หากท่านต้องการเข้าร่วมในการวิจัยนี้ โปรดติดต่อ “ยินยอม” ในสารวัจจุบัน ถ้าท่านมีคำถามเกี่ยวกับโครงการวิจัยนี้ ท่านสามารถติดต่อสอบถามจากผู้วิจัยคือ นางสาวสิริลักษณ์บริรักษ์ ได้ทางอีเมล S.Borirug@murdoch.edu.au หรืออาจารย์ที่ปรึกษาคือ รองศาสตราจารย์ ดร.แลนซ์ ฟุง (Associate Professor Dr. Lance Fung) ได้ทางอีเมล l.fung@murdoch.edu.au อาจารย์ที่ปรึกษาและผู้วิจัย
ยินดีที่จะตอบคำถามทุกคำถามที่ท่านสงสัยเกี่ยวกับการวิจัย และหากท่านต้องการทราบผลสรุปการวิจัยในครั้งนี้ ท่านสามารถแจ้งความจำนง และผู้วิจัยจะทำการส่งข้อมูลให้ท่านผ่านทางอีเมล์หลังจากเดือนมาคม ปี พ.ศ. 2555 เป็นต้นไป

ถ้าท่านให้ความยินยอมในการเข้าร่วมการวิจัยนี้ กรุณากดปุ่ม "Next" เพื่อเข้าสู่บทเรียน และหากไม่ประสงค์จะเข้าร่วมการวิจัย กรุณากดปุ่ม "Cancel" เพื่อปิดหน้าจอ
Appendix D: Copies of Pre, Post, and Final Questionnaires and Satisfaction Questionnaire

Appendix D-1: English Version of Pre, Post, and Final Questionnaires

The purpose of this study is to assess cognitive load reduction on educating traffic rules measured from the scores of the pre-test, post-test, and final-test questions. The aim of this form is to make a judgment of reviewing the test questions in order to measure the instruments of this study.

If you have any questions about this project please feel free to contact either myself, Sirilak Borirug via email S.Borirug@murdoch.edu.au or my supervisor, Associate Professor Dr. Lance Chun Che Fung via email l.fung@murdoch.edu.au. If you have any enquiries and want to talk to an independent person about your concerns, you can contact Murdoch University’s Human Research Ethics Committee on email ethics@murdoch.edu.au.

This portion relates to your acceptance of the questions. Please select only one answer for each of the following questions that best describe your opinion.

1. This sign means?
   - Hospital emergency entrance head
   - Ambulance station ahead
   - A crossroad intersection ahead
   - Helicopter landing pad ahead

2. This sign means?
   - Road narrows
b. Railway crossing ahead
c. End of divided road
d. Road widens ahead

3 This sign means?

![45km/h sign]

a. 45km/h is the legal maximum speed limit for the curve ahead when the road is wet
b. 45km/h is the advised maximum speed to travel around the curve ahead under good driving conditions
c. Winding road for next 45 kilometres
d. You can only turn right for the next 45 kilometres

4 This sign means?

![60 km/h sign]

a. Drive the vehicle not exceeding 50 km/hr
b. Drive the vehicle at 50 km/hr.
c. Drive the vehicle exceeding 50 km/hr.
d. All answers are correct

5 When turning right at an intersection where there is a stop sign, and a stop line painted on the road, you should?

![Stop sign]

a. Slow down and if it is safe, drive through the intersection
b. Stop only if traffic is coming from the right
   Stop at the solid white line at the intersection and give way to all vehicles and to all pedestrians on the road you're turning into
d. Stop, only for pedestrians

6 When traffic lights turn from green to yellow you should

a. Stop, even if you must stop on the intersection and then reverse back to the stop line
b. Stop, even if you are in the intersection
c. Stop, if you can do so safely before reaching the stop line
d. Speed up and go through the lights before they turn red

7 A yellow edge line along the side of the road means -

a. Fire hydrant indicator
b. Vehicles may stop to drop off or pick up passengers
c. No stopping or parking at any time
d. Parking for taxis only

8 What does this sign mean?

\[\text{\textbullet}\text{\textbullet}\text{\textbullet}\]

a. Construction zone ahead
b. Hospital ahead
c. Railroad crossing ahead
d. Roundabout ahead

9 What does this sign represent?

\[\text{\textbullet}\text{\textbullet}\text{\textbullet}\]

a. Stop ahead
b. Traffic light ahead
c. School zone ahead
d. Reduced speed zone ahead

10 What does this sign mean?

\[\text{\textbullet}\text{\textbullet}\text{\textbullet}\]

a. Divided highway begins, two-lane highway ends
b. Two-lane highway begins, divided highway ends
c. Yield
d. Merging traffic

11 What does this sign represent?

\[\text{\textbullet}\text{\textbullet}\text{\textbullet}\]

a. No trucks allowed
b. No passing zone for trucks
c. Trucks must yield to other vehicles
d. Hill ahead

12 What is the meaning of this sign?

\[\text{\textbullet}\text{\textbullet}\text{\textbullet}\]

a. Give way
b. No overtaking
c. National speed limit
13 What is the meaning of this sign?

- a. No entry
- b. Give way to traffic on your right
- c. No left turn
- d. No right turn

14 This road sign means:

- a. All traffic must turn right
- b. No right turn
- c. All traffic must go straight ahead
- d. Side Road

15 Speeding is dangerous because –

- a. Increasing speed also increases the severity of crashes
- b. Driving too fast around a corner can affect the vehicles stability
- c. The faster you drive, the more time and space you need to stop
- d. All of the above

16 What is the legal alcohol concentration for a driver?

- a. 0.00%
- b. 0.01%
- c. 0.02%
- d. 0.05%

17 A two-way left turn lane in the centre of the road means

- a. You can turn left or right from this lane
- b. You can pass other cars in this lane
- c. Cars traveling in both directions can turn left from this lane
- d. You can park in this lane

18 When driving in ideal conditions, how far should your car be from the car in front of you?

- a. 2 seconds behind
- b. 3 seconds behind
- c. 4 seconds behind
- d. In ideal conditions, it doesn’t matter
19 Which of the following statements is correct
a. Passengers in vehicles are less likely to be injured in a crash if they are wearing seat belts
b. The nature of injuries in motor vehicle crashes is not related to the wearing of seat belts
c. Passengers in rear seats of a vehicle are not required to wear seat belts
d. Only passengers over the age of 8 years must wear a seat belt

20 When should you use seat belts or appropriate child car restraints in a car
a. Only on the weekends
b. During the day
c. Every time you travel in a car
d. Not necessary

21 Unless signs tell you otherwise, the speed limit in cities and towns is
a. 80 km/h
b. 30 km/h
c. 50 km/h
d. 60 km/h

22 Which journeys should seat belts be used on
a. Only on short trips
b. Only on long trips
c. All trips
d. On the highway

23 What does a broken white line down the centre of a road mean
a. You must not cross the broken white line
b. You may only cross the broken white line to turn right
c. You must cross the broken white line when overtaking or turning right, if it is safe to do so
d. You must not stop on the broken white line

24 Are you allowed to make a ‘U’ turn at traffic lights
a. Yes
b. No, unless there is a ‘U’ TURN PERMITTED sign
c. Yes, if the traffic lights are not working
d. Yes, can make a 'U' turn anytime

25 You want to fit a baby restraint to your car. What should you secure the restraint to
   a. Only at the back using the seat belt provided
   b. An anchorage point designed for a baby restraint
   c. Any seat belt in the back or front of the car
   d. Only at the front using the seat belt provided

26 You are driving Vehicle A. You must give way to
   a. No-one (you go first)
   b. Vehicle B
   c. Vehicles B, D and maybe Vehicle C
   d. Vehicles B and C

27 You are driving Vehicle A. Which vehicles must you give way to
   a. Vehicles D and B
   b. Vehicles B and C
   c. Vehicles D and C
   d. Vehicles B, C and D

28 Vehicle A wants to turn right at an intersection with green traffic lights. It should indicate and
171

a. Give way to oncoming traffic and pedestrians crossing the road it is turning into
b. Give way to oncoming traffic and pedestrians crossing the road it is turning into
c. Turn quickly, oncoming traffic must give way
d. Turn quickly, oncoming traffic must give way

29 If you are being followed too closely while driving, you should
a. Drive closer to the car in front of you
b. Speed up to increase the distance between you and the following vehicle
c. Slow down and keep to the left, allowing the following vehicle to pass
d. Maintain your speed and move right to block the following vehicle from passing

30 How long does alcohol stay in your body?

a. Two hours for one standard drink
b. One hour for one standard drink
c. One and a half hours for one standard drink
d. Three hours for one standard drink
Appendix D-2: Thai Version of Pre, Post, and Second Post Questionnaires

The research project was conducted to study the efficiency of using virtual reality techniques to teach traffic rules to undergraduate students in Thailand. The aim was to reduce cognitive load in learning and to enhance the learning efficiency by conducting this test to evaluate the efficiency of the tools developed by the researcher. The test consists of 30 questions and an evaluation questionnaire to assess the satisfaction of the learning process.

If you have any questions or concerns, please contact S.Borirug@murdoch.edu.au or Associate Professor Dr. Lance Chun Che Fung at l.fung@murdoch.edu.au. If you need to contact Murdoch University’s Human Research Ethics Committee, you can email ethics@murdoch.edu.au.

Please select only 1 answer.

1. This sign means:
   a. Emergency department entrance
   b. Fire station is in front
   c. Front is a pedestrian crossing
   d. Helicopter parking

2. This sign means:
   a. Narrow
   b. Railroad crossing
   c. End of intersection
   d. Front is an extension
3 เครื่องหมายนี้หมายถึงอะไร

![Image](image1.jpg)

a. จำกัดความเร็วสูงสุด 45 กิโลเมตรต่อชั่วโมงสำหรับให้ขับหน้าเมื่อถนนเปียก
b. แนะนากำวเร็วสูงสุด 45 กิโลเมตรต่อชั่วโมงในระยะโต้โอกาสข้างหน้า
c. ข้า่งหน้ามีทางโค้งเสียวกับระยะ 45 กิโลเมตร
d. เลี้ยวขวาในอีก 45 กิโลเมตรข้างหน้า

4 เครื่องหมายนี้หมายถึงอะไร

![Image](image2.jpg)

a. ใช้ความเร็วไม่เกิน 50 กิโลเมตรต่อชั่วโมง
b. ขับที่ความเร็ว 50 กิโลเมตรต่อชั่วโมง
c. ขับที่ความเร็วเกิน 50 กิโลเมตรต่อชั่วโมง
d. ถูกทุกข้อ

เมื่อเปิดสัญญาณเสียวกำวข้างแยก ที่มียุยให้หยุด และเส้นพื้นถนนแสดงให้หยุด ผู้ขับควรทำอย่างไร

5

![Image](image3.jpg)

a. ชะลอ และถ้าปลอดภัยให้ขับผ่านทางแยกได้
b. หยุด เมื่อมีรถมาทางข้างหน้าเท่านั้น
c. หยุดรถที่เส้นขาวที่ทางแยก และให้ทางรถทุกคัน รวมถึงคนข้ามถนนที่ทางที่กำลังไป
d. หยุดรถให้คนข้ามถนนเท่านั้น

เมื่อสัญญาณจราจรเปลี่ยนจากเขียวเป็นเหลือง เราควรทำอย่างไร

6

![Image](image4.jpg)

a. หยุด ควรหยุดที่ทางแยก และรอรถกลับไปหลังเส้นให้หยุด
b. หยุด แล้วข้ามอยู่ที่ทางแยก
c. หยุดสำหรับเรือสินค้าขนาดใหญ่หรือเรือที่มีผู้โดยสาร

d. หยุดภายในเขตพื้นที่ป้องกันไฟไหม้

7. เส้นขอบเหลืองข้างถนนหมายถึง

a. ขอบของเขตที่จอดรถ
b. เส้นสีเหลืองที่จุดที่อาจเกิดอุบัติเหตุ

8. เครื่องหมายนี้หมายถึงอะไร

a. มีป้ายที่สั่งห้ามขับรถ
b. มีป้ายที่สั่งห้ามขับรถ

9. เครื่องหมายนี้หมายถึงอะไร

a. ให้หยุดที่สี่แยก
b. สัญญาณจราจรที่สี่แยก

10. เครื่องหมายนี้หมายถึงอะไร

a. เบี่ยงทางที่สี่แยกที่มีรถesper, หมายถึง 2 เส้น
c. หยุดให้ทาง
<table>
<thead>
<tr>
<th>11</th>
<th>เครื่องหมายนี้หมายถึงอะไร</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d. รวมการจราจร</td>
<td>11</td>
<td>เครื่องหมายนี้หมายถึงอะไร</td>
</tr>
<tr>
<td></td>
<td>a. ไม่อนุญาตให้รถบรรทุกเข้า</td>
<td>b. ไม่ให้รถบรรทุกผ่าน</td>
<td>c. รถบรรทุกด้วยผ่อนให้พาหนะอื่นผ่านไปก่อน</td>
</tr>
<tr>
<td>12</td>
<td>เครื่องหมายนี้หมายถึงอะไร</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. ให้ทาง</td>
<td>b. ห้ามแซง</td>
<td>c. จำกัดความเร็ว</td>
</tr>
<tr>
<td>13</td>
<td>เครื่องหมายนี้หมายถึงอะไร</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. ห้ามเข้า</td>
<td>b. ให้ทางกับรถทางขวาก่อน</td>
<td>c. ห้ามเลี้ยวซ้าย</td>
</tr>
<tr>
<td>14</td>
<td>เครื่องหมายนี้หมายถึงอะไร</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ต้องเลี้ยวขวาทางเดียว
ห้ามเลี้ยวขวา
ให้ตรงไปอย่างเดียว
ข้างถนน

การใช้ความเร็วในการขับขี่ก่อให้เกิดอันตราย เนื่องจาก
ความเร็วที่เพิ่มขึ้นเป็นการเพิ่มแรงในการชน
การขับขี่ที่ใช้ความเร็วสูงในทางเลี้ยวมีผลต่อเสถียรภาพในการขับขี่
ขับโดยใช้ความเร็วก็เป็นการเพิ่มเวลาและระยะในการจอดรถ
ถูกทุกข้อ

กฏหมายกำหนดปริมาณแอลกอฮอล์ ของผู้ขับขี่ที่เท่าไหร่
0.00%
0.01%
0.02%
0.05%

ช่องทางเลี้ยวซ้าย 2 ช่องทางในช่องกลางของถนนหมายถึง
สามารถเลี้ยวขวา หรือ ช้ายได้จากช่องทางนี้
สามารถขับผ่านจากข้างชนิดเดิมในช่องทางนี้
รถที่กำลังกลับหน้าไป ต้องทิ้งทาง สามารถเลี้ยวซ้ายได้จากช่องทางนี้
จอดรถได้ที่ช่องทางนี้

ขณะขับขี่ ควรเว้นระยะห่างจากรถคันข้างหน้าไกลแค่ไหน
2 วินาที
3 วินาที
4 วินาที
ไม่กำหนด
19 ข้อใดต่อไปนี้ถูก
a. ผู้โดยสารจะบาดเจ็บน้อยลงเมื่อรัดเข็มขัดนิรภัย
b. การรัดเข็มขัดนิรภัยไม่มีผลต่อการกระแทก
c. ผู้โดยสารด้านหลังไม่จำเป็นต้องรัดเข็มขัด
d. ผู้โดยสารอายุ 8 ปีขึ้นไปต้องรัดเข็มขัด

20 เมื่อไหร่ควรใช้เข็มขัดนิรภัย
a. เปการั้วหยุดด้วยล้อหน้า
b. ถนนกลางวัน
c. ทุกระยะเมื่อขับรถ
d. ไม่จำเป็น

21 จําเป็นความเร็วในเมืองที่เท่าไหร่
a. 80 กิโลเมตรต่อชั่วโมง
b. 30 กิโลเมตรต่อชั่วโมง
c. 50 กิโลเมตรต่อชั่วโมง
d. 60 กิโลเมตรต่อชั่วโมง

22 เส้นทางไหนควรรัดเข็มขัดนิรภัย
a. เปการะยะทางสั้นๆ
b. เปการะยะทางไกลๆ
c. ทุกระยะทาง
d. เ pokabaka งะทางด่วน

23 เส้นประสีขาวตรงกลางถนนหมายถึงอะไร
a. ไม่ให้ข้ามเส้นประสีขาว
b. ให้ข้ามเส้นประสีขาวเมื่อเลี้ยวขวา
c. ให้ข้ามเส้นประสีขาวเมื่อแซงหรือเลี้ยวขวา เมื่อในระยะปลอดภัย
d. ห้ามหยุดบนเส้นประสีขาว

177
24 สามารถกลับรถที่บริเวณสัญญาณจราจรได้หรือไม่

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>ใช่</td>
</tr>
<tr>
<td>b.</td>
<td>เฉพาะที่อนุญาตให้ทำได้</td>
</tr>
<tr>
<td>c.</td>
<td>ใช่ ถ้าสัญญาณจราจรไม่ทำงาน</td>
</tr>
<tr>
<td>d.</td>
<td>ใช่ ทำได้ตลอด</td>
</tr>
</tbody>
</table>

25 ต้องการนำที่นั่งเด็กทารก ขึ้นรถ ควรทำอย่างไร

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>ไว้ข้างหลังและใช้เข็มขัดนิรภัย</td>
</tr>
<tr>
<td>b.</td>
<td>ตรงจุดที่ยึดเหนี่ยวสำหรับที่นั่งเด็กทารก</td>
</tr>
<tr>
<td>c.</td>
<td>ได้ทุกที่นั่ง</td>
</tr>
<tr>
<td>d.</td>
<td>เฉพาะส่วนหน้าที่มีเข็มขัดนิรภัยเตรียมไว้</td>
</tr>
</tbody>
</table>

26 ถ้าคุณขับรถ A คุณควรให้ทางกับรถคันใด

![Diagram](image)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>ไม่ต้อง เวลาไปก่อน</td>
</tr>
<tr>
<td>b.</td>
<td>รถคัน B</td>
</tr>
<tr>
<td>c.</td>
<td>รถคัน B, D และอาจจะเป็นคัน C</td>
</tr>
<tr>
<td>d.</td>
<td>รถคัน B และ C</td>
</tr>
</tbody>
</table>

27 ถ้าคุณขับรถ A รถคันใดควรให้ทางแก่คุณ
28 รถคัน A ต้องการเลี้ยวขวาที่สัญญาณจราจรขณะไฟเขียว รถคันนี้ควรแสดงสัญญาณอะไร

- a. ให้ทางแก่รถที่กำลังวิ่งเข้ามา และคนข้ามถนน
- b. ให้ทางแก่รถที่กำลังวิ่งเข้ามา และคนข้ามถนน
- c. เลี้ยวอย่างเร็ว ไม่ต้องให้ทางแก่รถที่วิ่งมา
- d. เลี้ยวอย่างเร็ว ไม่ต้องให้ทางแก่รถที่วิ่งมา

29 ถ้ามีรถขับตามมาใกล้เกินไป ผู้ขับขี่ควรทำอย่างไร

- a. ขับเข้าไปให้ใกล้รถคันหน้า
- b. เข้ามาเร็ว เพื่อเพิ่มระยะทางระหว่างรถ
- c. ชะลอรถและขับชิดซ้าย เพื่อให้คันหลังแซงไป
- d. คงความเร็วเท่าเดิม และขับชิดขวา เพื่อปิดทางไม่ให้รถคันหลังแซงไปได้
แอลกอฮอล์คงอยู่ในร่างกายของผู้ดื่มได้นานแค่ไหน

a. 2 ชั่วโมงต่อการดื่มในระดับมาตรฐาน
b. 1 ชั่วโมงต่อการดื่มในระดับมาตรฐาน
c. 1 ชั่วโมงครึ่งต่อการดื่มในระดับมาตรฐาน
d. 3 ชั่วโมงต่อการดื่มในระดับมาตรฐาน
## Appendix D-3: English Version of Satisfaction Questionnaire

### Statement of user satisfaction

<table>
<thead>
<tr>
<th>1. Perceived usefulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using this learning instruction as a tool for learning traffic rules increases my learning and knowledge</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
<tr>
<td>Using this learning instruction enhances the effectiveness of my learning and knowledge in regard to traffic rules</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
<tr>
<td>This learning instruction allows me to progress at my own pace</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
<tr>
<td>This learning instruction is useful in supporting my learning traffic rules</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
<tr>
<td>I am completely satisfied with this learning instruction experience</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
<tr>
<td>I am completely satisfied with the teaching methods applied in this learning instruction environment</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
<tr>
<td>I am completely satisfied with this learning instruction environment</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
<tr>
<td>This learning instruction motivates me to learn</td>
</tr>
<tr>
<td>1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree</td>
</tr>
</tbody>
</table>
9 This learning instruction makes learning more motivating and interesting
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

10 This learning instruction helps me to enhance my understanding
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

11 This learning instruction allows me to learn better
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

12 This learning instruction can improve my performance in regard to the topic of traffic rules
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

13 This learning instruction would make it easier to learn about traffic rules
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

2. Perceived ease of use

14 Learning how to use this learning instruction (about traffic rules) is easy for me
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

15 It is easy for me to find information with this learning instruction
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

16 Overall, I think this learning instruction is easy to use
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

17 Learning to operate this learning instruction would be easy for me
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

18 I would find it easy to get this learning instruction to do what I want it to do
1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

19 My interaction with this learning instruction would be clear and understandable
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

It would be easy for me to become skillful (about traffic rules) using this learning instruction

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

It requires the fewest steps possible to accomplish what I want to do with this learning instruction

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

This learning instruction makes the memorization process easier

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

This learning instruction makes the comprehension process easier

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

I can use this learning instruction successfully every time

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

3. Perceived value

I quickly became skillful (about traffic rules) using this learning instruction

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

The presentation of this learning instruction content is clear

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

The quiz in this learning instruction and its embedded materials enhance my learning process

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

I am completely satisfied with the overall learning effectiveness of this learning instruction

1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
29 I really enjoyed this learning instruction very much
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
30 I think I am pretty good at using this learning instruction
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
31 It was important for me to do well at this learning instruction
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
32 Learning with this learning instruction was quite fun
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
33 I would describe this learning instruction as "very interesting"
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
34 I am completely satisfied with my performance in this learning instruction
   environment
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
35 I did not try very hard while learning with this learning instruction
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
36 While learning with this learning instruction, I was thinking about how much I
   enjoyed it
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
37 I was very relaxed while learning with this learning instruction
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
38 I am pretty skilled at using this learning instruction
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
39 Using this learning instruction, I can learn much about traffic rules and regulations
   1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
This learning instruction helps me to better apply what is learned

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

This learning instruction allows me to have more control over my own learning

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

Using this learning instruction, I am able to link the new knowledge with my previous knowledge and experiences (about traffic rules)

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

4. Perceived system quality

I feel very confident learning this learning instruction

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

The structure of the learning instruction keeps me focused on what is supposed to be learned

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

The presentation of the subject content is clear

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

The materials provided in this learning instruction clearly contain originality and creativity in terms of the visual design and layout

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

The graphics used in the materials are appropriate

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

The colors used in the materials are appropriate

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree

The links provided in the material are clearly visible and logical

1 Strongly Disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly Agree
50 The links provided are relevant and appropriate to the document
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

51 The links provided are reliable. No inactive links were found.
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

52 The graphical user interface makes it suitable for using this learning instruction
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

53 The program directions and navigations are clear
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

54 Navigation is very easy on this learning instruction
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

55 I can find required information easily on this learning instruction
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

56 In this learning instruction, I can easily navigate where I want
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree

57 This learning instruction is a good educational portal and improves my learning on traffic rules
1 Strongly Disagree  2 Disagree  3 Neutral  4 Agree  5 Strongly Agree
## แบบทดสอบความพึงพอใจ

<table>
<thead>
<tr>
<th>1. ประโยชน์ที่ได้รับ</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>แบบเรียนนี้ช่วยเพิ่มความรู้ด้านการจราจรได้</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>แบบเรียนนี้เพิ่มประสิทธิภาพในการเรียนรู้ได้</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>แบบเรียนนี้ช่วยพัฒนาการเรียนรู้แบบก้าวกระโดด</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>แบบเรียนนี้มีประโยชน์ต่อการสนับสนุนการเรียนรู้ด้านการจราจร</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>ฉันมีประสบการณ์ที่น่าพอใจในการเรียนกับแบบเรียนนี้</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>ฉันพอใจกับหลักการสอนที่ได้รับจากสภาพแวดล้อมของแบบเรียนนี้</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>ฉันพอใจกับสภาพแวดล้อมของแบบเรียนนี้</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>แบบเรียนนี้ช่วยให้ฉันมีความตื่นเต้นในการเรียน</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>แบบเรียนนี้ทำให้การเรียนมีความมุ่งมั่นและดีขึ้น</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
<tr>
<td>แบบเรียนนี้ช่วยให้ฉันมีความก้าวหน้าในการเรียนรู้</td>
<td>1</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>2</td>
<td>ไม่เห็นด้วย</td>
<td>3</td>
</tr>
</tbody>
</table>
แบบเรียนนี้ช่วยให้ฉันเรียนรู้ได้ดียิ่งขึ้น
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ช่วยเพิ่มประสิทธิภาพในการเรียนเรื่องกฎจราจร
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ช่วยให้การเรียนรู้กฎจราจรง่ายขึ้น
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

2. ง่ายต่อการใช้ประโยชน์

แบบเรียนนี้ง่ายสำหรับฉันต่อการเรียนรู้ (เกี่ยวกับกฎจราจร)
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

ง่ายสำหรับฉันในการหาข้อมูลในแบบเรียนนี้
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

โดยรวม ฉันคิดว่าแบบเรียนนี้ง่ายต่อการใช้งาน และการเรียนรู้
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ง่ายสำหรับฉันต่อการจัดการต่อการเรียน
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

ขั้นตอนความง่ายต่อการได้สิ่งที่ฉันต้องการจากแบบเรียนนี้
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

ปฏิบัติการของฉันต่อแบบเรียนนี้โดยภาพ และข้อความที่ได้รับ
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

มันง่ายสำหรับฉันต่อการเพิ่มความรู้ ความช้าฐานอนุกิจเกี่ยวกับกฎจราจร โดยเรียนจากแบบเรียนนี้
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

ใช้ขั้นตอนง่ายๆมากพอเพื่อได้มาซึ่งสิ่งที่ต้องการในแบบเรียนนี้
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ทำให้มีกระบวนการจำได้ง่ายขึ้น
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ทำให้ข้ามบทเรียนไปง่ายขึ้น
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

ฉันสามารถใช้แบบเรียนนี้ได้ทุกเวลา
1. ไม่เห็นด้วยอย่างยิ่ง 2. ไม่เห็นด้วย 3. ปานกลาง 4. เห็นด้วย 5. เห็นด้วยอย่างยิ่ง

3. คุณค่าที่ได้รับจากแบบเรียน
| 25 | ฉันได้รับความรู้ความช้านานยุกต์กับกฎจราจรได้เร็วขึ้นจากการใช้แบบเรียนนี้ | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 26 | การนำเสนอเนื้อหาของแบบเรียนนี้มีความชัดเจน | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 27 | ฉันได้รับความรู้ความช้านานยุกต์กับกฎจราจรได้เร็วขึ้นจากการใช้แบบเรียนนี้ | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 28 | ฉันไม่เห็นด้วยอย่างยิ่ง | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 29 | การนำเสนอเนื้อหาของแบบเรียนนี้มีความชัดเจน | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 30 | ฉันไม่เห็นด้วยอย่างยิ่ง | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 31 | การนำเสนอเนื้อหาของแบบเรียนนี้มีความชัดเจน | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 32 | ฉันไม่เห็นด้วยอย่างยิ่ง | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 33 | การนำเสนอเนื้อหาของแบบเรียนนี้มีความชัดเจน | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 34 | ฉันไม่เห็นด้วยอย่างยิ่ง | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 35 | การนำเสนอเนื้อหาของแบบเรียนนี้มีความชัดเจน | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 36 | ฉันไม่เห็นด้วยอย่างยิ่ง | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 37 | การนำเสนอเนื้อหาของแบบเรียนนี้มีความชัดเจน | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
| 38 | ฉันไม่เห็นด้วยอย่างยิ่ง | 1 | ไม่เห็นด้วยอย่างยิ่ง | 2 | ไม่เห็นด้วย | 3 | ปานกลาง | 4 | เห็นด้วย | 5 | เห็นด้วยอย่างยิ่ง |
ฉันสามารถเรียนรู้กฎจราจรได้มากด้วยการเรียนแบบนี้

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ช่วยให้ฉันสามารถนำสิ่งที่ได้เรียนไปใช้ได้อย่างชัดเจน

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ช่วยให้ฉันควบคุมการเรียนรู้ของตัวเองได้ดียิ่งขึ้น

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

แบบเรียนนี้ทำให้ฉันสามารถเชื่อมโยงความรู้ใหม่ๆ เช้ากับความรู้และประสบการณ์เกี่ยวกับ

การเรียนรู้ได้อย่างดี

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

4. คุณภาพของแบบเรียน

ฉันรู้สึกมั่นใจเมื่อเรียนด้วยแบบเรียนนี้

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

โครงสร้างของแบบเรียนนี้ช่วยให้ฉันสามารถนำสิ่งที่ได้เรียนไปใช้ได้อย่างชัดเจน

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาระที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง

ภาพที่นำเสนอในเนื้อหาค่อนข้างเหมาะสม

1. ไม่เห็นด้วยอย่างยิ่ง
2. ไม่เห็นด้วย
3. บางกลาง
4. เห็นด้วย
5. เห็นด้วยอย่างยิ่ง
<table>
<thead>
<tr>
<th>การชี้ทางและการนำทางเพื่อความชัดเจน</th>
<th>ไม่เห็นด้วยอย่างยิ่ง</th>
<th>ไม่เห็นด้วย</th>
<th>ปานกลาง</th>
<th>เห็นด้วย</th>
<th>เห็นด้วยอย่างยิ่ง</th>
</tr>
</thead>
<tbody>
<tr>
<td>การชี้ทางทำการเรียนง่ายขึ้น</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>ไม่เห็นด้วย</td>
<td>ปานกลาง</td>
<td>เห็นด้วย</td>
<td>เห็นด้วยอย่างยิ่ง</td>
</tr>
<tr>
<td>ขั้นตอนข้อมูลที่ต้องการได้ง่ายขึ้นในแบบเรียนนี้</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>ไม่เห็นด้วย</td>
<td>ปานกลาง</td>
<td>เห็นด้วย</td>
<td>เห็นด้วยอย่างยิ่ง</td>
</tr>
<tr>
<td>ขั้นสามารถตั้นทางที่ต้องการได้ง่ายในแบบเรียนนี้</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>ไม่เห็นด้วย</td>
<td>ปานกลาง</td>
<td>เห็นด้วย</td>
<td>เห็นด้วยอย่างยิ่ง</td>
</tr>
<tr>
<td>แบบเรียนนี้ถือว่าเป็นประตูในการศึกษาและพัฒนาการเรียนรู้กฎจราจรได้ดี</td>
<td>ไม่เห็นด้วยอย่างยิ่ง</td>
<td>ไม่เห็นด้วย</td>
<td>ปานกลาง</td>
<td>เห็นด้วย</td>
<td>เห็นด้วยอย่างยิ่ง</td>
</tr>
</tbody>
</table>
Appendix E: Ethic Approval Letter

Research Ethics Office
Division of Research and Development

Thursday, 21 July 2011

Dr Lance Fung
School of Information Technology
Murdoch University

Dear Lance,

**Project No.** 2011/139

**Project Title** The Study of the Effectiveness on Virtual Experiential Learning (VEL) for Cognitive Load Reduction on Educating Thai Undergraduate Students on Traffic Rules

Thank you for addressing the conditions placed on the above application to the Murdoch University Human Research Ethics Committee. On behalf of the Committee, I am pleased to advise the application now has:

**OUTRIGHT APPROVAL**

Approval is granted on the understanding that research will be conducted according the standards of the *National Statement on Ethical Conduct in Human Research* (2007), the *Australian Code for the Responsible Conduct of Research* (2007) and Murdoch University policies at all times. You must also abide by the Human Research Ethics Committee’s standard conditions of approval (see attached). All reporting forms are available on the Research Ethics web-site.

I wish you every success for your research.

Please quote your ethics project number in all correspondence.

Kind Regards,
Dr. Erich von Dietze  
Manager of Research Ethics  
cc: Dr Kevin Wong  
Sirilak Borirug

Human Research Ethics Committee: Standard Conditions of Approval

a) The project must be conducted in accordance with the approved application, including any conditions and amendments that have been approved. You must comply with all of the conditions imposed by the HREC, and any subsequent conditions that the HREC may require.
b) You must report immediately anything which might affect ethical acceptance of your project, including:
   - Adverse effects on participants
   - Significant unforeseen events
   - Other matters that might affect continued ethical acceptability of the project.
c) Where approval has been given pending copies of documents such as letters of support / consent from other organisations or approvals from third parties, these must be provided to the Research Ethics Office before the research may commence at each relevant location.
d) Proposed changes or amendments to the research must be applied for, using an Amendment Application form, and approved by the HREC before these may be implemented.
e) An annual Report must be provided by the due date specified each year (usually the anniversary of approval) for the project to have continuing approval.
f) A closure report must be provided at the conclusion of the project.
g) If, for any reason, the project does not proceed or is discontinued, you must advise the committee in writing, using a Closure Report form.
h) If an extension is required beyond the approved end date of the project, an extension application should be made allowing sufficient time for its consideration by the committee. Extensions cannot be granted retrospectively.
i) You must advise the HREC immediately, in writing, if any complaint is made about the conduct of the project.
j) Any equipment used must meet current safety standards. Purpose built equipment must be tested and certified by independent experts for compliance with safety standards.
k) Higher degree students must have both Candidacy and Program of Study approved prior to commencing data collection.
l) You must notify the Research Ethics Office of any changes in contact details including address, phone number and email address.
m) The HREC may conduct random audits and / or require additional reports concerning the research project.

Failure to comply with the National Statement on Ethical Conduct in Human Research (2007) and with the conditions of approval may result in the suspension or withdrawal of approval for the project.

The HREC seeks to support researchers in achieving strong results and positive outcomes.

The HREC promotes a research culture in which ethics is considered and discussed at all stages of the research. If you have any issues you wish to raise, please contact the Research Ethics Office in the first instance.