

Developing an Attention Framework for Road Sign Design Assessment using the Principle of Emphasis

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Abstract: Graphic design has been proven to have an impact on human perception in areas such as consumerism. One would argue that a similar impact could exist in the area of transportation as well. The main objective of this research is to determine the factors that influence human attention in responding to visual cues. This was accomplished by exploring human attention from the point of view of design principle and feature integrated theory. As attention is the first process that occurs in the human cognitive process after visual stimulation happens, it is crucial to define the factors that contribute towards the stimulation to road sign design. Using Design and Development Research (DDR) approaches, this study involved three phases which were needs analysis, development, and evaluation. Methods such as interview, Fuzzy Delphi and Expert Review were also used. This research aims to establish a framework that consists of several design principles and visual elements that are accountable for the visual attention of motorists. This research findings are expected to contribute towards Malaysia Road Safety 2014-2020 Plan, specifically in the second pillar as well as Safer Road and Mobility programme and stimulate many research interests involving design principles in the transportation area of the future.

1 INTRODUCTION

As one of the oldest safety and traffic control equipment (Kazemi et al. 2016) road signs assist road users in terms of giving orders, warning, directions, and information (Ezeibe et al. 2018). An effective road sign is the one which commands attention, communicate a simple meaning and give sufficient time to road users to make a proper response (Bañares et al. 2018). Starting from establishing attention to influencing viewers' responses, road sign designers aim to create effective road sign designs using design principles as guidance. Fundamental theories in design claim that emphasis is a principle that is responsible for attracting viewers' attention (A. Lauer & Pentak 2012; Graham 2002).

Bearing this in mind, this research will analyse the connection between the emphasis on the design principles and school road signs design at selected school within Klang Valley. Thorough studies will be conducted on how school road signs successfully attract drivers' attention. The study will also measure the level of design standardisation

application of the school road signs, in the hope of establishing evidence that ineffective road signs are one of the factors that caused road accidents in Klang Valley.

The intention of this study is to examine road sign designs in relation to news reporting of road accidents, especially involving school children. Although the news reports about road accidents may be regarded as another ordinary news to Malaysians, mail from Bukit Aman Traffic Investigation and Enforcement Department (*Jabatan Siasatan dan Penguatkuasaan Trafik Bukit Aman (JSPTBA)*), indicated that the total number of road accident deaths was as high as 6570 in 2016. As the rate of death per 100,000 population in the same year was 24 people, the number of road fatalities resulted in Malaysia being ranked as one of the top countries with high road accident death when compared with similar income nation in the world, behind Kazakhstan and Libya. This was worsened by the fact that road traffic deaths involving road users below 20 years old in Malaysia formed 24% of the total number of road accident deaths in 2017 (World Health Organization 2015).

As example, on 21 February 2018, two school pupils were hit by a car in front of Sekolah Kebangsaan Santong Paka in Dungun, Terengganu. The incident happened in the morning (Ilham 2018). Another fatal accident involved a year two student of Sekolah Kebangsaan Air Baruk, Melaka who was hit by a car on 4th January 2018. Mohammad Faris Zakwan Zainuddin was dragged for 15 meters under a Proton Iswara driven by the school's general worker (Koh 2018).

2 PROBLEM STATEMENT

Human plays a crucial role in road accidents (Janpla et al. 2015) as speeding was blamed as the major cause of the problem (Bham & Leu 2018; Ezeibe et al. 2018; Zhao et al. 2016). Hence, a serious effort should be taken to understand human factors in relation to road safety such as suggested by Dr. Ir. Muhammad Marizwan Bin Abdul Manan from the Malaysian Institute of Road Safety Research (MIROS). In his presentation on Motorcycle Crashes in Malaysia: Status, Risk Factors, and Interventions, one of his suggestions for future research was to study the Motorcycle Behaviour at Pedestrian Crossing (Abdul Manan 2015). This is given the fact that most schools in the country have its road crossing for a safety measure for pedestrians.

Many researchers are in agreement about the importance of road signs as a countermeasure to reduce the occurrence of road accidents. Zhao et al. (2016) emphasised on the need to place special signage to alert drivers within the surroundings of the schools since the findings of their studies indicated that certain road devices might improve driving performance and road safety.

According to Bañares et al. (2018), a good road sign is capable of attracting attention from road users to communicate the message before the next process follow suit. Commanding attention is the second principle stated in the United States of America's Manual on Uniform Traffic Control Devices as a guideline when addressing road sign and other traffic control devices application (Federal Highway Administration 2009). Similar principles can be seen applied to the Malaysian general principles of traffic sign where the signs should be conspicuous in order to attract driver's attention (Public Works Department of Malaysia 1985).

Effective road sign helps save lives. The problem will occur when road users fail to pay attention to road signs (Bin et al. 2013). Several factors has been recognised as the reasons for inattention such as

information overload (Kaplan et al. 2018; Kazemi et al. 2016; Topolšek et al. 2016), not enough contrast between the road signs and the environment (Bin et al. 2013) as well as the drivers' age (Zahabi et al. 2017).

The efforts to understand the psychology of attention had been initiated more than one hundred years ago as seen in a research conducted by Johansson and Backlund in 1970 about the relationship between road signs and attention (Costa et al. 2018). They tested the attention of the drivers by evaluating their memories of road signs seen by the participants as they passed these signs. Shinar and Drory (1983) confirmed the results obtained by Johansson and Backlund when they conducted a similar study with different respondents. Other research in this area included Costa et al. (2014) who evaluated the attention given to vertical road signs and Kazemi et al. (2016) regarding the level of attention given to urban road signs.

Using a systematic literature review, the researcher found the lack of research papers published regarding the relationship between attention and road signs in regards to design principles. There are some elements such as space (Liu & Wang 2013; Tejero et al. 2018b) and contrast (Rahman & Strawderman 2015) on paper, but as much as visual principles are concerned as there are more properties to scrutinise. In this case, visual factors contributing to attention stimulation should be scrutinised from an art and design perspective.

Additionally, in the second pillar of the Malaysia Road Safety 2014-2010 Plan which is safer road and mobility, the Malaysian government aimed to regularly re-evaluate the standards and rules regarding road safety issues (Road Safety Department of Malaysia 2014)

Since design principles affect human attention, the researcher believes that by systematically investigating this matter, it would contribute to a better understanding of road sign design in the future.

3 LITERATURE REVIEW

3.1 Design Principles

The study about how individual part in an artwork can influence the whole visual perception of human was conducted by Christian von Ehrenfels in his essay titled On 'Gestalt Qualities' (Smith 1988). Later, a group of physiologists namely Max

Wertheimer, Wolfgang Kohler, and Kurt Koffka extended the theory. Gestalt theory involves the principles of similarity, continuation, focal point, figure-ground, belongingness, balance, proximity, common fate, and closure.

Table 1: Design Principles list.

Visual Principles	Authors						
	a	b	c	d	e	f	g
Balance	x	x	x	x	x	x	x
Unity			x	x	x	x	x
Emphasis		x		x	x	x	x
Rhythm	x		x	x	x	x	x
Variety	x				x		x
Hierarchy					x		x
Dominance	x						x
Proportion	x		x	x	x	x	x
Scale				x	x	x	x
Movement	x						x
Repetition	x	x			x		x
Contrast	x	x	x	x			
Alignment		x					
Flow		x					
Harmony	x			x			
Economy	x						
Proximity					x		x
Similarity					x		
Continuity					x		
Closure	x				x		
Common Fate					x		
Continuing Line					x		
Visual Linking	x						
Elaboration	x						
Focal Point							x

a = Ocvirk et al. (1998). b = Graham (2002). c = Prust (2003). d = Pipes (2008). e = Landa (2011). f = A. Lauer & Pentak (2012). g = Evans & Thomas (2013)

Table 1 shows the analysis of various modern design principles established by several references. It can be seen that some of the Gestalt principles mentioned previously had been absorbed as part of design principles by these authors. The list was made of a combination of the main and secondary principles. Based on the list, the researcher made a comparative analysis. Even though some of the terms carry similar meaning, they were maintained as they are for later analysis. There is no exact number of principle elements agreed by these theorists, but we can see the similarity in the meaning and intention after reading the details.

Another comparison was also made by the researcher to examine the link between viewers'

perceptual effects of these principles as suggested by the theorists. It was found that emphasis was the main element needed for establishing a focal point (Evans & Thomas 2013; Landa 2011; Pipes 2008) and grabbing viewers' attention (A. Lauer & Pentak 2012; Graham 2002). Other design principles such as balance, created a pleasing composition effect (Graham, 2002) while unity tended to make the whole design solution look like one entity (Pipes 2008; Prust 2003).

3.2 Defining Attentions.

Attention is a noun used to describe the concentration of the mind on something. It also carries the meaning of bringing something to knowledge (Dewan Bahasa dan Pustaka 2018). Hornby (2000) in Oxford Fajar dictionary gave four definitions of attention. It is an action where someone is applying his or her mind to something or someone. It is also defined as an act of taking special care of something or someone. The third definition is a kind of thoughtful action of a person, and the last definition is a drill position, where a soldier standing upright with feet together and arms stretched downwards. The definition given by these two dictionaries conveys a shared meaning. This is in comparison with a more precise interpretation of the term attention given by psychologists.

James (1890), a psychologist, defined the term attention as holding in control clearly and vividly one thought out of several thoughts that have been concurrently stimulated. The clearness of the sensory process was defined by Titchener and Wundt (Kazdin 2000). Attention is part of cognitive psychology (Kellogg, 2003) and one of the important aspects when someone is driving (Tejero et al. 2018a). This theory can be visualised by looking at the information-processing model of memory (Watts & Lazarus 2008) presented in Figure 1.

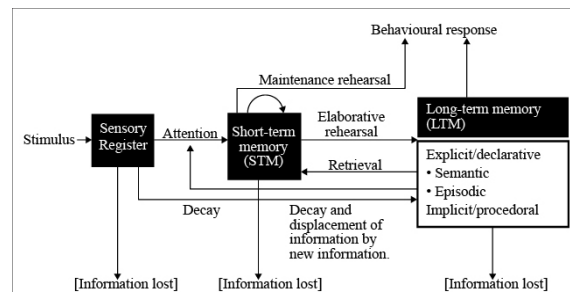


Figure 1: Information-processing model of memory (Watts & Lazarus 2008).

Attention activity happens after the stimuli become registered by the sensory. Many of the stimuli perceived daily by people will be lost from the memory system without further processing or saved in the storage. In order to response to the stimuli, a person must first give attention to it. An important stimulus should be able to grab the attention of the viewer because it usually happens at the early stage of the human memory system.

Giving attention to visual cue can be explained using the Visual Attention Theory. Kellogg (2003) described attention as a beam of a spotlight and he later segregated attention into two categories which are selective attention and divided attention. Selective attention occurs when an adjacent stimulus is ignored, focusing the attention only on a small diameter of highlight compared to divided attention where adjacent stimuli get some processing such a diffused beam of the spotlight.

While inattention is the antonyms of attention (Merriam-Webster 2018), a study found that 93% of vehicle collisions and minor accidents were contributed from inattention while driving (Dingus et al., 2006). Inattention can be caused by being distracted by a secondary task such as driving-related activities that prevent the driver from looking forward. These activities include drowsiness and non-driving related eye glances. This study's finding is in line with the claim made by Bin et al. (2013) who argued that inattention is one of the main factors that instigate road accidents and assertion by Malaysian Minister of Transport, Datuk P. Kamalanathan that drivers do not look at warning signs (Bernama, 2016).

There are a number of factors why drivers fail to pay optimal attention to the driving activity from the perspective of psychology. These factors can be divided into two categories: endogenous and exogenous factors (Underwood et al., 2003). High workload causes reduced cognitive resources making drivers fall short of using their existing knowledge to expect hazard to intrude into the current road environment in an endogenous factor. The exogenous factor is when the road user fails to attend to sudden changes in the visual field such as an object moving into the field of view. As a road sign can be a visual cue for reminding road users to allocate a certain amount of attention towards possible hazards to come in the context of the endogenous factor, this study aims to improve the driver's attention factor towards the road sign.

3.3 Road Signs

Paying attention to the road environment is very crucial, and road sign helps the driver to perform better during the driving activity. A good road sign will give hints to drivers about what to expect on the road ahead, and it has the capability to change a driver's attitude when approaching a certain area. It also should help the driver to anticipate in advance any unexpected situation ahead (Wickens et al. 2004). (Cian et al. 2015) added that how the content is presented can help the driver to evaluate better and change his/her behaviour accordingly. Conspicuous road signs also can stimulate the attention of the driver and consequently improve his/her comprehension of the surroundings (Kaplan et al. 2018).

The role of effective road sign installations in reducing traffic accident has been proven as reported by the International Road Federation in 2006. Their data indicated that there was a 41% decrement in the road rate of accidents in the United Kingdom as a result of effective road sign installations (Ezeibe et al. 2018). United Nations Economic and Social Council (1968) in the Vienna Convention on Road Signs and Signals also claimed that the installation of three road sign categories helped to reduce the rate of road accidents. These road sign categories included the danger warning signs, regulatory signs, and informative signs. Within these categories, there were subcategories of signs that were employed to help drivers be alert of the road environment. In the local context, installing road sign has been suggested besides imposing a speed limit and providing awareness to help reduce road accident (Hassan 2018; Mohamed et al. 2011).

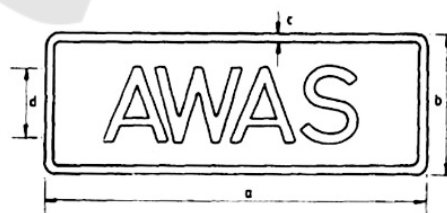


Figure 2: Layout design as suggested by Public Works Department of Malaysia (1985).

Jabatan Kerja Raya Malaysia (JKR) or Public Works Department of Malaysia has imposed standard guidelines for sign installations for various road conditions. Figure 2 shows a guideline for the layout template for a road sign with text and Figure 3 illustrates a school road sign installation guide.

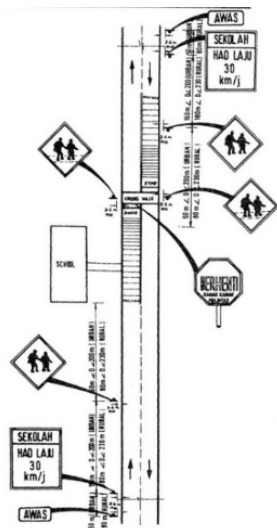


Figure 3: The location of school signs as suggested by Public Works Department of Malaysia (1985)

Various research had been conducted to investigate how road users interact with road signs. These research can be divided according to the stages of the road user and road sign interaction process. The processes could be segregated according to the stimulate, recognise and read, decision-making and behave stages (Bin et al. 2013). This segregation is in alignment with the information-processing model of memory (Watts & Lazarus 2008) in Figure 1.

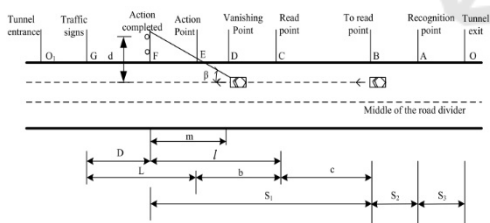


Figure 4: Stages of driver's responses to road signs (Bin et al. 2013).

With reference to Figure 4, the road sign in F initiates the attention-grabbing process at the first stage (A), then the driver should be able to read and recognise the message in Stage Two (B to C). Later, the driver will have to make a decision in Stage Three (C to E) and finally execute the decision in the form of a response at the behave stage (E). The claim made by Bin et al. (2013) is in line with the suggestion by Bañares et al. (2018) that grabbing

attention from the driver is the first process before other processes happen.

3.4 Road Accident Reality in Malaysia

Malaysia's fatality rate per population of 100,000 is twenty-four people; it is one of the highest fatality rates in the world and six times greater than Singapore (World Health Organization 2015). Brunei, which is another high-income nation within the ASEAN region with a significantly low fatality rate of 5.8 in 2004 (Center MIROS-ASEAN Road Safety, 2016). The Malaysian rate of road fertility is considerably high and time is running out for Malaysia since the World Bank predicts that Malaysia will become a high-income nation as early as 2024 (Bernama 2018).

Table 2: ASEAN countries road fatality rate by income group (Center MIROS-ASEAN Road Safety 2016).

Fatalities per 100,000 population	Low Income	Middle Income	High Income
Low (<10)			Brunei Singapore
Medium (10-15)		Philippines Laos PDR	
High (>15)	Cambodia Myanmar	Indonesia Malaysia Thailand Vietnam	

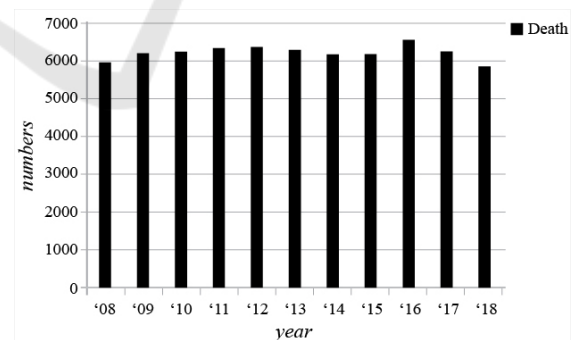


Figure 5: Cases of fatal road accident in Malaysia from 2008 to 2018.

The number of road accident fatalities in Malaysia is relatively consistent from 2009 until 2017 with more than 6000 deaths, as JSPTBA confirmed in Figure 5. More scientific studies should be conducted to tackle this problem so more lives can be saved effectively.

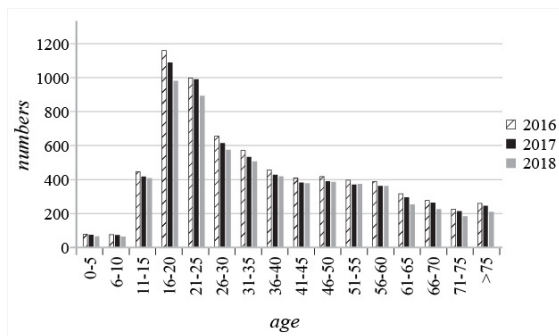


Figure 6: Road accident fatalities in Malaysia based on age.

Figure 6 illustrates the number of people involved in fatal accidents based on age in recent years. The peak age for deaths caused by road accidents is between sixteen to twenty years old. In 2018, children and teenager group constitute 24% of the overall sum involved in fatal road accidents. The population from this age group are those who still go to school in Malaysia, from pre-school until to the Upper Sixth Form or just starting their college life.

With 154,958 cases of road accidents that occurred in 2017, Selangor has become the highest contributor to road accident cases in Malaysia, as presented in Figure 7. Johor and Kuala Lumpur come after that with more than 70,000 cases. Compared to the Road Safety Department of Malaysia's (2018) report, this graft is consistent with the number of registered vehicles in each state with Kuala Lumpur recording 6,328,245 registered vehicle followed by Johor and Selangor. Since Kuala Lumpur is situated inside Selangor, we can assume that the Klang Valley has the highest amount of road accidents and the utmost number of vehicles.

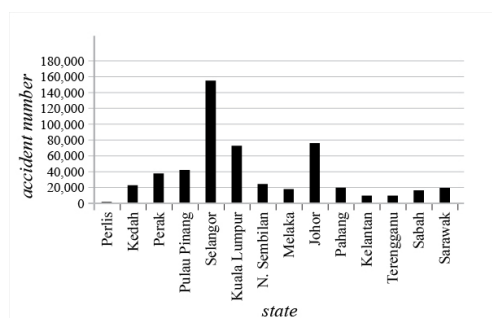


Figure 7: Road accident rates in Malaysia in 2017 based on states.

In terms of factors influencing road accidents, Malaysian statistical results show no difference from the rest of the world. Accidents caused by speeding (32.8%), careless driving (28.2%) and careless overtaking (15.1%) have been the most significant

contributing factor. The driver's behaviour is the major cause of road accidents, contributing up to 76.1% of all the causes of road accidents (Redhwan & Karim 2010).

4 CONCEPTUAL FRAMEWORK

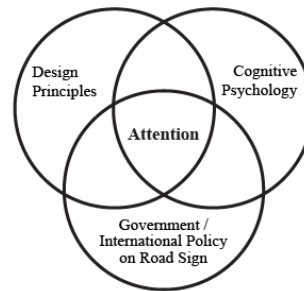


Figure 8: Three different knowledge resources combined to establish this research platform.

This research framework is based on three knowledge sources as defined in Figure 8, which are Design Principles; Cognitive Psychology and road sign design policy from Malaysia Government and international institution. Independent variables will be encapsulated from Design Principles as suggested by two selected sources, Landa (2011) and (Ocvrk et al. 1998) shown in Figure 9. Understanding attention psychology and experimental methodology for this study will be referring to previous established visual attention study such as Feature Integration Theory (Treisman & Galade 1980). Resources for Malaysian road sign design will be coming from government documentation such as *Arahan Teknik (Jalan) 2A/85: Manual on Traffic Control Devices* (Public Works Department of Malaysia 1985a).

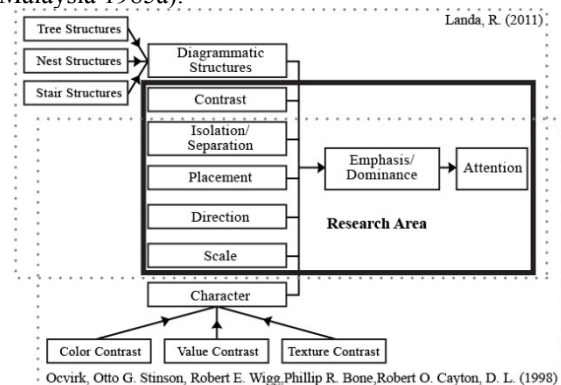


Figure 9: Theoretical emphasis concept defined by Landa (2011) and dominance concept by Ocvrk et al. (1998).

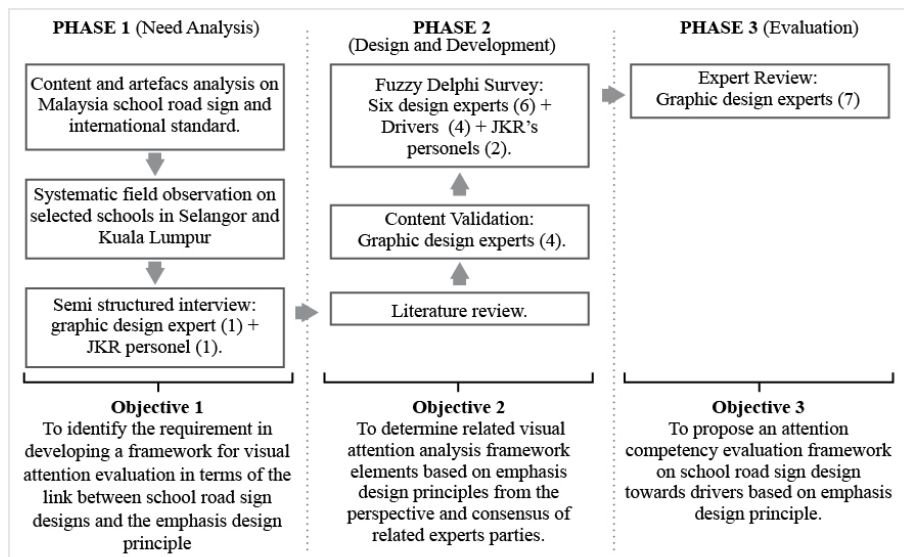


Figure 10: Research methods employed in this study.

5 OBJECTIVES

In order to develop the attention framework to enable road sign assessment, this study has three objectives:

- i) To identify the requirement in developing a framework for visual attention evaluation in terms of the link between school road sign designs and the emphasis design principle.
- ii) To determine the related visual attention analysis framework elements based on the emphasis design principles from the perspective and consensus of design experts.
- iii) To propose an attention competency framework for the school road sign design for drivers based on the emphasis design principles.

These objectives are aligned with the Design and Development Research (DDR) methodology that will be explained later.

6 METHOD OF STUDY

Using the Type Two Design and Development Research (DDR) methodology as suggested by (Richey & Klein 2007), this study will utilise the mixed method in achieving its objectives. It is divided into three phases to address the objective of each phase as illustrated in Figure 10.

6.1 Phase One

In this needs analysis phase, it is crucial to identify the problem, theories, concept and subject matter to develop a framework for visual attention evaluation pertaining to the road signs for Malaysian schools.

Content analysis including artefacts studies and a comparison with two other countries (Singapore and United Kingdom school road signs) will be conducted to form a clear picture of the current system of school road signs in Malaysia. These countries were selected based on their low rate of accidents in the world (World Health Organization, 2015). This will be accomplished by referring to a related document from JKR (1985) which is the Arahan Teknik (Jalan) 2A/85: Manual on Traffic Control Devices and Traffic Sign Application and Arahan Teknik (Jalan) 2B/85: Manual on Traffic Control Devices and Traffic Sign Application.

A systematic observation activity will be held at selected schools with road accident history within the last two years in the study area to record the effectiveness of the road sign installation. Systematic documentation regarding the condition and the design implementation will be recorded during the observation.

All the data from the artefact analysis and observation will be used as a basis for the semi-structural interview questions. Two interview sessions will be held with a design expert and another with the JKR personnel who is in charge of the road sign designs and installations. These two interview respondents will be selected based on the

expert definition proposed by Mustapha and Darusalam (2018).

6.2 Phase Two

Three steps are anticipated in Phase 2 in order to determine the related elements in visual attention analysis framework based on the emphasis design principles.

A literature review will be performed to bring together any information and data regarding emphasis design principle and its application in attracting the attention of drivers. This information will later be compared with the findings of the previous stage of the study and divided into several constructs and sub-construct elements. This list of elements will then be presented to four graphic design experts in signage in order to get their opinion and consensus regarding the suitability of the elements to be included in the Fuzzy Delphi survey later.

Six selected design experts, four expert drivers, and two JKR personnel will be chosen to participate in the Fuzzy Delphi session in order to get the final list of constructs and sub-constructs of the emphasis design principles for the school road sign evaluation. These participants will be selected as suggested in the Fuzzy Delphi requirements (Mustapha & Darusalam, 2018). The ambiguity of this area is the main reason why the Fuzzy Delphi method is selected so that the related elements of emphasis can be identified.

6.3 Phase Three

In this evaluation phase, the expert review by seven graphic design experts from different companies and academic institutions will be conducted. The aim is to validate the framework about the importance of the selected elements, the relationship between the elements, and the relevance in assessing the attention factor of the sign. They will receive a detailed description of the framework and sub-framework with a set of questionnaire. The levels of agreement based on the Likert scale will be used ranging from (1) "I strongly disagree" to (5) "I strongly agree" to answer the questions. The expert will also be prompted to comment on their ratings and to give suggestions for improvements.

7 DISCUSSION

Due to the high number of road accidents in Malaysia, there is a critical need for effective countermeasures strategies to alleviate the problem. Although several scholars have touched on this issue, there is still a paucity of research which focuses on the perspective of art and design. This research provides an alternative point of view in road sign designs in order to increase the level of attention to the road signs and reduce road accident.

7.1 Measuring Tool to Assess the Objective of the Road Sign System.

Five principles have been listed in the *Arahan Teknik (Jalan) 2B/85: Manual on Traffic Control Devices and Traffic Sign Application* (JKR, 1985), the guide book for the installation of the road sign system in Malaysia. These principles consist of the installation objectives such as illegibility of the sign, noticeability, and effectiveness during the day or night. As mentioned earlier, there are needs for evaluation to measure the success of each of these principles. This study will eventually create a tool to assess the second principle, which is the capability to attract the attention of drivers at a sufficient distance and the ability to be easily recognizable as traffic signs at a distance. The framework from this study may be used as an analysis tool complimenting other methods such as digital simulation test.

As this study focuses on the second principle, other assessment tools should also be developed, as there are many principles to be addressed. The real issue of the sign can be seen clearly after each principle has been attended to.

7.2 Determining the Characteristics of the Emphasis Design Principle in Road Sign Design.

This research will systematically identify the elements of attention to road sign using the principle of emphasis design. These elements may be carried out in the future as more research efforts are needed especially in experimental research to observe the effects of road signage on human's attention. It is hoped that extensive research can result in a better road sign design in the future.

7.3 Creating a Guideline for a Designer in Designing Road Signs that Attract the Attention of Road Users

Road signs are visual cues for motorists in preparing them to expect things they might confront in front. It is crucial especially as warning signs to gain the attention of motorists and preparing them for any eventualities of danger. Evaluating existing road signs and redesigning a better version require guidelines. The framework could assist designers in coming out with an improved road sign design before it can be tested for effectiveness.

7.4 Revision of the Malaysian Road Sign and Signal Guidelines (*Arahan Teknik Jalan*)

The references for road sign installation in Malaysia are based on a series of *Arahan Teknik Jalan* series by Public Works Department of Malaysia. An examination of the latest version of the guidelines stated in the Guide Signs Design and Application (ATJ 2E/87 (Pindaan 2015)), indicated that there is an urgency for a revision of guidelines particularly with regards to the graphical aspect of road sign specifications and visualisations. The outdated colour codes for spot colour and inconsistency between the illustrations and numbering measurements need to be addressed. Since Malaysia is one of the top countries with a high accident rate and since Malaysia is not part of the Geneva Sign and Signal 1968 Convention, it is critical that the road safety aspects be given prominence and an updated guideline regarding road signs could be one of the methods that can offer a solution.

8 CONCLUSION

The attention given to road signs, especially the warning signs is fundamental to ensure safety while driving. It can save lives and improves the driving experience. This research will focus on developing a framework to measure the factors that attract drivers attention to road sign designs. The outcome may be used as a guideline in the pre-production and production stage as well as the maintenance of road signs. Further research related to visual principles should be conducted in the future in order to generate more research paths for improving road sign designs. Studies like the impact of a dynamic icon by Cian et al. (2015) or other future research

that examines the emphasis factors determined from this research would be of value.

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