International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Public Perception on Motorcyclist Safety Prevention Methods using Structural Equation Modelling

N H Mokhtar, Mukhtar M F, Luqman Hamzah, Husni C. Mamat, M M Zamberi

Abstract: *Motorcycle-related road accidents are the most frequent cause of road traffic injuries reported in Malaysia. One of the key approaches of the Safe System strategy used internationally to address the road casualty reduction goals and targets for interim and long term planning was by improving the vehicle safety system. In this study, feedback regarding the prevention methods that could help reduce the occurrence of motorcycle accidents was obtained from drivers and motorcyclists. In total, five components of safety prevention methods were established and quantitative data were measured from a set of questionnaires distributed all over Malaysia. The questionnaires were designed to understand the public perception on effective methods to address the current road safety issues. Items in the questionnaire were analysed by Structural Equation Modelling using AMOS 25.0 to enable an informed decision based on the data obtained. The primary objectives of this study are to assess the validity and reliability of the measurement model using structural equation modelling based on the public perception of motorcyclists safety prevention methods. In this study, all the measurement models achieved their validity and reliability at the required level. The fitness index based on CR and AVE values were higher than 0.50, thereby indicating that the measurement model achieved the level of acceptance required. In addition, the constructed variables were statistically significant based on the factor loading values that were greater than 0.6 for each construct.*

Keywords: *Motorcyclist Safety, Public Perception, Structural Equation Modelling*

Revised Manuscript Received on December 30, 2019.
* Correspondence Author

N H Mokhtar *, Fakulti Teknologi Kejuruteraan Mekanikal Pembuatan, Universiti Teknikal Malaysia Melaka, Malaysia. Email: nurhazwani@utem.edu.my

Mukhtar M F, Fakulti Teknologi Kejuruteraan Mekanikal Pembuatan, Universiti Teknikal Malaysia Melaka, Malaysia. Email: fariduddin@utem.edu.my

Luqman Hamzah, Fakulti Teknologi Kejuruteraan Mekanikal Pembuatan, Universiti Teknikal Malaysia Melaka, Malaysia: luqmanhakim@utem.edu.my

Husni C. Mamat Fakulti Teknologi Kejuruteraan Mekanikal Pembuatan, Universiti Teknikal Malaysia Melaka, Malaysia. Email: zulhusni@utem.edu.my

M M Zamberi, Fakulti Teknologi Kejuruteraan Mekanikal Pembuatan, Universiti Teknikal Malaysia Melaka, Malaysia. Email: mahanum@utem.edu.my

I. INTRODUCTION

Over the past few decades, there has been a decline in infectious diseases and an increase in deaths and disabilities due to injuries.

Malaysia, a middle-income country, is not excluded from the impact of these incidents as road traffic deaths and injuries have caused an enormous strain on the country's healthcare system. For instance, more than 6000 Malaysians are killed annually on the roads and many more are seriously injured.

The increasing number of injuries is related directly to the increasing number of road users. In 2006, the number of motorcycles registered were 15,790,732 and in 2016, the number increased substantially to 12,933,042 [1]. Based on the road traffic accidents index, the death rate was 24.2 per 100,000 of the population, while the road traffic index for every 10,000 registered vehicles was 3.40 in 2015.

To date, motorcycle-related road accidents are the most frequent cause of road traffic injuries reported in Malaysia. One of the key approaches of the Safe System [2] strategy used internationally to address the road casualty reduction goals and targets for long term and interim planning was by improving the vehicle safety system. Road accidents involving a motorcyclist often leads to death. Road crashes are the leading cause of mortality for young people aged between 1 to 23 years old [3]. In this age group, teenagers and young adults are especially at risk of getting involved in road traffic accidents due to their risky driving behaviors on the road. Every year, many critical injuries and even death cases occur [4]. In low- to middle-income Asian countries, motorcycles are the most common form of transportation for the general public. According to the latest analysis of motorcycle crash statistics, the National Highway Traffic Safety Administration (NHTSA) reported that although there were fewer motorcyclists killed in 2014 compared to 2013 [5], there was a 5% increase in the number of injuries. It is evident that protective equipment may reduce the number of deaths, although other factors related to the upward trend in motorcycle injury need to be determined. Furthermore, it was reported that the injury rate per 100 million vehicle miles travelled increased from 434 in 2013 to 459 in 2014 [3]. Therefore, preventive measures and clinical care should be focused on this group of road users to reduce the overall burden of road traffic injuries in Malaysia.

Driving require a few stages of information processing, perception, recognition, prediction, decision, response selection and task execution. The essential elements to understand the cognitive process when humans are driving are situation awareness and mental workload [6].

This study was performed to obtain feedback regarding the prevention methods that could reduce the occurrence of motorcycle accidents. In total, five components of prevention methods were established in this study. Questionnaires were distributed all over Malaysia to understand the public perception of methods that could effectively address road safety issues and quantitative data were analysed based on the questionnaire responses. The items listed in the questionnaires were then analysed by structural equation modelling using AMOS 25.0. This method was used to determine the relationship between the factors analysed in this study to enable an informed decision based on the data obtained.

II. RESEARCH METHODOLOGY

A. Conceptual Framework

Several factors relating to the reduction of motorcycle accident rates and fatalities were identified prior to this study. At present, some of the key factors identified to solve this issue include driving education, law enforcement, the efficiency of infrastructure, motorcycle safety technology, and car safety technology. The conceptual framework established for this research is illustrated in Fig 1.

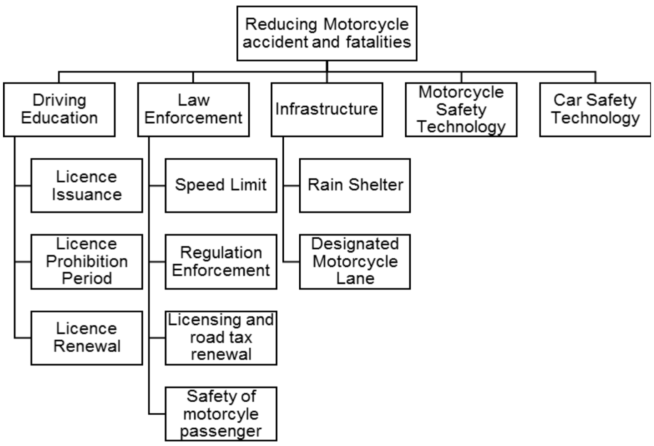

Fig. 1: Research Framework

Driving education was one of the essential factors identified to reduce accidents and fatalities. The implementation of driver education programs significantly reduces crashes and traffic violations {Formatting Citation}. Due to the high accident crash rates involving young drivers, it is now compulsory for new drivers to enroll for lessons via in-class education and in-vehicle training. Additionally, since it is mandatory for every driver to obtain a drivers' licence, the introduction of these driver education programs may help reduce the number of accidents.

Secondly, law enforcement is critical for the implementation of any successful road safety strategy. However, this method varies depending on several factors such as individual circumstances, environment, and cultures. Some of the common strategies used in Malaysia include speed limits, regulation enforcement, renewal of drivers' licence and road tax, and creating awareness on the safety of the motorcyclists and their passengers. Apart from education and law enforcement, the third factor is related to the efficiency of the infrastructure developed for motorcyclists. It is also important to note that there is a need for improved infrastructures for road users due to the recent increase in vehicle usage over the years. For motorcyclists, infrastructures such as efficient rain shelters and designated motorcycle lanes are thought to facilitate their safety on the road.

Another factor that contributes to the increase in motor accidents is car safety. Nowadays, vehicles designed with advanced safety technologies are rapidly entering the marketplace and the introduction of these new features are enhancing the safety of road users. Hence, the decrease in human errors due to careless driving behaviours can potentially reduce traffic collision dramatically [8].

B. Structural Equation Modelling Analysis

In this study, a comprehensive statistical analysis technique known as Structural Equation Modelling (SEM) was employed to determine the relationship among variables. SEM is a method commonly used for assessing and modifying measurement models as well as structured models. This method is used to assess the unidimensionality, validity, and reliability of the measurement model. SEM is a multivariate technique that simultaneously estimates a series of inter-related dependent relationships. The hypothesised model can be tested for its significance through the simultaneous analysis of the entire system of variables to check for consistencies with the data.

In SEM, the structural relationship between the measured variables and latent construct is analysed. Latent variables have an abstract character and cannot be measured directly, while questionnaire surveys can be used to measure the construct variables [7].

In SEM, the relationship between variables is determined by their Fitness Index (FI) value that reflects on how the model fits the sample data. In addition, it is not necessary to satisfy all the FI values as long as it fits at least one FI from each fitness index category. Table 1 shows the information for the fitness index categories and their respective levels of acceptance.

Table 1: Fitness Index for SEM

Fitness Index Category	Index Name	Level of Acceptance
Absolute Fit	Root Mean Square of Error (RMSEA)	< 0.08
	Goodness of Fit Index (GFI)	> 0.90
Incremental Fit	Tucker-Lewis Index (TLI)	> 0.90
Parsimoniou s Fit	Chi Square/Degree of freedom (Chisq/df)	< 0.50

The validity and reliability of the model are essential elements in a measurement model. The validity of the measurement model is verified through the Average Variance Extracted (AVE). AVE represents a measure of the average percentage of variation captured by the items in a construct. The value of AVE should be greater or equal to 0.5 to achieve convergent validity. Reliability, on the other hand, is the extent of how reliable the measurement model measures the intended latent constructs. Construct reliability is the measure of reliability and internal consistency of the measured variables that represent a latent construct. To achieve construct reliability, a value of CR $\geq$ 0.6 is required. The theoretical formulas to calculate the values of CR and AVE, respectively, are as follows:

III. RESULTS AND DISCUSSION

A. Demographics of Participants

The questionnaire survey employed in this study was distributed all over Malaysia. Respondents were randomly selected based on their various locations and age groups. In total, survey responses from 373 respondents, consisting of 254 males and 119 females, were collected. Over 95% of the respondents received a university degree qualification, while approximately 2% received qualifications from other educational institutions.

Among the 373 respondents, 30% and 4% never owned a motorcycle and driving licence, respectively. The majority of the respondents had their motorcycle and driving licence for more than fifteen years. Hence, the information gathered based on their experience and opinion was essential for this research study. The types of licences held based on the number of years of owning a vehicle licence are shown in Fig. 2. As part of this study, an initial evaluation of the respondents was also performed in relation to their involvement in any road accidents. Interestingly, 42.1% of the respondents were never involved in accidents, 30.3% were involved in accidents as a driver and motorcyclist and the rest were involved separately as either drivers or motorcyclists (Fig. 3). Hence, it is possible that their involvement in a road accident would influence the outcomes of the study.

The variables analysed in this study were selected from a variety of questions that were based on the construct variables. Respondents were required to choose answers that were available based on a graded choice scale (Likert scale 1-5), ranging from disagree to completely agree.

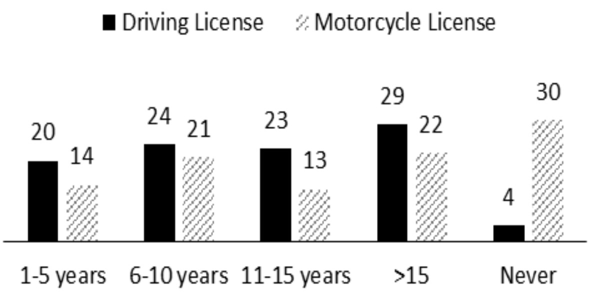

Fig. 2: Types of Licences Held

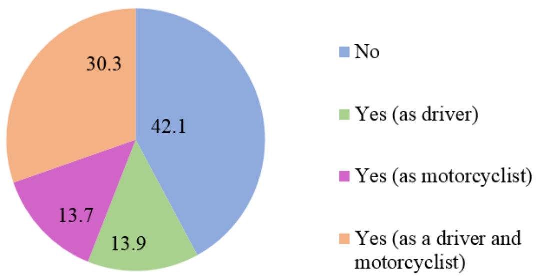

Fig. 3: Bar chart illustrating the involvement of respondents in road accidents

B. Confirmatory Factor Analysis (CFA): Measurement model

CFA is a unique form of factor analysis used to test whether the measure of a construct is consistent with the researcher's understanding of the nature of that construct. In this study, the CFA technique was employed as a method for factor analysis. In SEM, the straight arrows from the latent variable were removed and only the arrows associated with the variable representing the covariance between every pair of latent variables were added.

In this study, SEM was initially applied to the data and followed by the Second Order Confirmatory Factor Analysis (SOCFA). SOCFA is a statistical method used to reconfirm that the theorised construct in a study is loaded into a certain number of underlying components. Every component has its measurement model and items. The First Order CFA (FOCFA) was initially applied to obtain the measurement model of the construct. The results of the factor loadings for the first order construct are illustrated in Fig. and the summary of the factor loadings, CR and AVE values are shown in Table 2.

Construct Reliability (CR)

$$\frac{(\Sigma\kappa)^2}{(\Sigma\kappa)^2+(\Sigma 1-\kappa^2)} \quad (1)$$

Average Variance Extracted (AVE)

$$\frac{\Sigma\kappa^2}{n} \quad (2)$$

κ - factor loading of every item

n - number of items in a model

Table 2: CFA Summary for all Constructs

Construct	Item	Factor Loading Values	CR (>0.6)	AVE (>0.5)
Education	A4	0.763	0.699	0.538
	A5	0.702		
Law Enforcement	B2	0.795	0.837	0.632
	B3	0.873		

	B4	0.709		
Infrastructure	C1	0.661	0.765	0.522
	C5	0.803		
	C7	0.696		
Motorcycle Safety Technology	D3	0.732	0.699	0.538
	D4	0.734		
Car Safety Technology	E3	0.793	0.887	0.664
	E4	0.775		
	E5	0.913		
	E7	0.770		

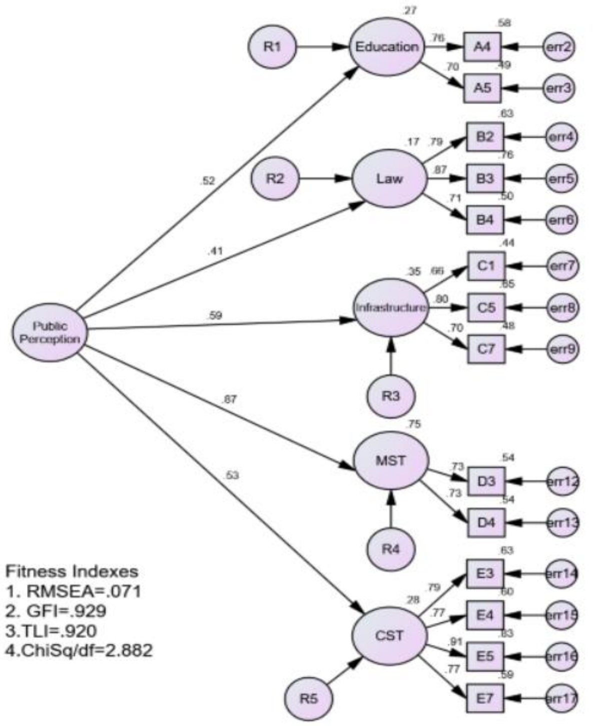

Fig. 4: The Factor Loadings for First Order Construct

Table 1 shows the finalised results after the elimination of latent variables with lower factor loading values. Factor loading values should be 0.7 or higher for acceptance in this study. The CFA results showed the computation of the remaining measures, thereby indicating the validity and reliability of the measurement model.

Overall, the results indicated that the general public agreed on the importance for drivers to undergo a driving education program before the issuance of a licence. For instance, the driving simulator training is one of the methods that could help improve driving ability as it provides a controlled driving environment with real-world traffic simulations (item A4). Another suggestion was to extend the period of probationary licence (P) (item A5) to ensure that the driver has sufficient time to develop their driving skills before receiving their full drivers' licence.

A previous study indicated that one of the main factors that caused motorcycle accidents was speeding [8]. Hence, reducing the speed limit may help decrease the number of accident cases (item B2). At present, the National Speed Limits enforced in 1989 have set the default speed limit for motorcycles at 110 km/h and 90 km/h on the expressway and federal state roads, respectively. However, it has been previously observed that motorcyclists seldom adhered to the speed limits [9]. Speeding increases the risk of getting into an accident as the driver may not react quickly enough if there is a mistake by another road user or an unexpected event on the road. However, it is still unknown whether the speeding behaviours of motorcyclists are similar to car drivers. Hence, the implementation of the AES/Speed Trap primarily for motorcyclists is recommended (item B3). Additionally, an alarm system to monitor the speed limit of motorcycles can also be incorporated to notify the driver when a certain speed is achieved (item B4).

The third construct is related to the development of efficient infrastructure for motorcyclists. For instance, infrastructures such as designated motorcycle lanes are key to reducing motorcycle accidents (items D3 and D4). It is evident that a motorcycle lane that is designated for motorcyclists is far more efficient than non-exclusive motorcycle lanes. These motorcycle paths should be placed at the far-left side of each roadway on federal roads and separated from the primary lanes by black-and-white stripe road markings, thus enabling the motorcyclist to overtake other motorcycles and exit the freeway safely.

Lastly, the implementation of novice technologies for motorcycles and cars may help reduce the occurrence of accidents. With the development of new technologies, automotive engineers could offer technological solutions to ensure the safety of motorists on the road. For example, the use of airbags was suggested (item D3), in which a wearable airbag vest was deployed immediately on the motorcyclist upon impact. In addition, a reflective motorcycle paint was also being implemented (item D4), in which this type of paint could help other drivers to see the motorcyclists clearer during rainy days as well as at night. Another technological aspect was to enhance car safety technology and ensure that drivers were aware of motorcyclists riding in their blind spot. A blind-spot alert system would be effective (item E3) as it alerts the driver when an object is at the blind spot. One of the car safety technologies that is now mandatory is the installation of AEB (item E5), a braking system that performs auto-braking when an obstacle is detected. Additionally, an efficient lane departure system will also be beneficial for car drivers as it alerts drivers who deviate from their respective lanes. At present, it is essential for owners to install the lane departure system in their vehicles (item E7). Fig. 5 shows the measurement model combining all constructs consisting of five first-order constructs relating to factors that reduce motorcycle accidents.

Table **3** shows the scores for regression weights for all the sub-constructs.

The results in

Table **3** indicated that the public perception on motorcyclists' safety had a significant effect on all five components. More importantly, the values reflect how well the model fits the data obtained in this study as all the fitness index values achieved their respective levels of acceptance required.

It can conclude that Motor Safety Technology (MST) is most important factor that effect the factor of public perception since the value of S.E is higher than other factors.

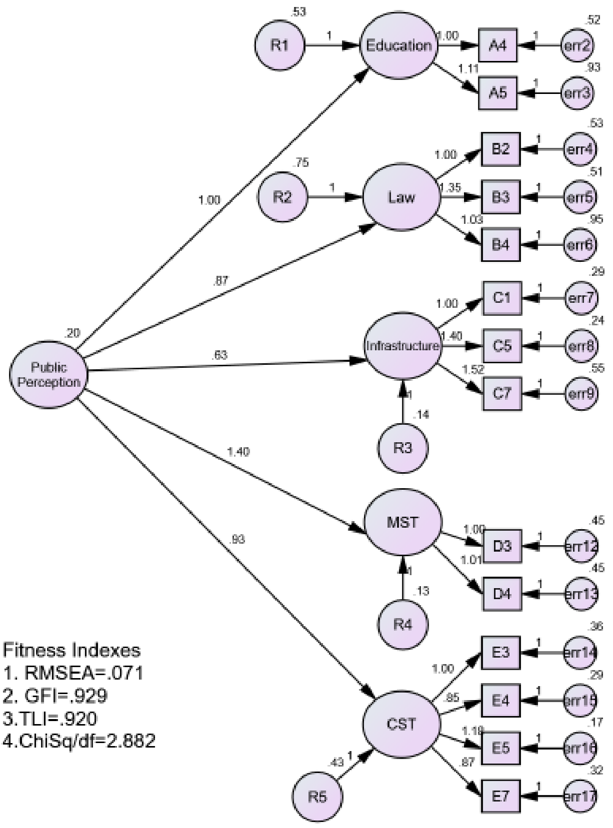

Fig. 5: The path regressions of public perception and the respective sub-constructs

Table 3: The path regression coefficient and significance values

		Estimate	S.E.	C.R .	P	Results
Education	←	Public Perceptio n	1	Reference Point		
Law Enforcement	←		0.8 7	4.54	0.00 1	Significan t
Infrastructure	←		0.6 3	0.12	0.00 1	Significan t
MST	←		1.4 0	0.26	0.00 1	Significan t
CST	←		0.1 8	5.23	0.00 1	Significan t

IV. CONCLUSIONS

The primary objectives of this study were to assess the validity and reliability of a measurement model using the structural equation modelling of public perception on the prevention of motorcycle-related accidents. In this study, all the measurement models achieved their validity and reliability values required. The fitness index based on the CR and AVE values were higher than 0.50, thereby indicating that the measurement model achieved the level of acceptance required [10].

In addition, the factor loading values for each construct was more than 0.6, thereby indicating that the constructed variables were statistically significant. In total, five factors which include driving education, law enforcement, the efficiency of infrastructure, motorcycle safety technology, and car safety technology were identified to prevent motorcycle accidents and fatalities on the road. It is hoped that the identification of these key factors will reduce the occurrence of motorcycle-related accidents and improve the understanding of accident behaviours in drivers.

REFERENCES

1. G. Indonesia, “Laporan Tahunan 2015 Annual Report : Caring with Passion to Serve,” pp. 1–198, 2015.
2. DaCoTa, “Vehicle Safety, Deliverable 4.8u of the EC FP7 project DaCoTA,” no. 2012, 2012.
3. Y. Puratmaja, L. Handayani, and K. S. Sunardi, “Factors Associated with Motorcycle Risk Behavior among Thai University Students, Khon Kaen,” *Int. J. Eval. Res. Educ.*, vol. 6, no. 4, p. 270, 2017.
4. N . H .MOKHTAR, H. TAKADA, and Y. MATSUURA, “Driver Reaction towards Unintended Acceleration in Automated and Silent Vehicle,” *Int. J. Affect. Eng.*, vol. 16, no. 1, pp. 43–51, 2017
5. J. M. Pirrung, “Motorcycle safety,” *Nursing (Lond).*, vol. 39, no. 2, p. 6, 2009.
6. N. H. Mokhtar, H. Takada, and Y. Matsuura, “Driver Respond to Pre-Collision Scenario at Intersection in Autonomous Vehicle,” *J. Adv. Manuf. Technol.*, vol. 13, no. No. 1 January-April 2019, pp. 109–118, 2019.
7. Z. M. Jawi, B. M. Deros, A. A. A. Rashid, M. H. M. Isa, and A. Awang, “The roles and performance of professional driving instructors in novice driver education,” *Sultan Qaboos Univ. Med. J.*, vol. 17, no. 3, pp. e277–e285, 2017.
8. P. Penmetsa, M. Hudnall, and S. Nambisan, “Potential safety benefits of lane departure prevention technology,” *IATSS Res.*, vol. 43, no. 1, pp. 21–26, 2019.
9. L. Zhao, B. Wang, J. Mbachu, and Z. Liu, “New Zealand building project cost and its influential factors: A structural equation modelling approach,” *Adv. Civ. Eng.*, vol. 2019, 2019.
10. P. Temmerman and M. Roynard, “Motorcycle Speed Survey 2014: Results of the First Motorcycle Speed Behaviour Survey in Belgium,” *Transp. Res. Procedia*, vol. 14, pp. 4218–4227, 2016.
11. A. N. Stephens, J. Brown, L. de Rome, M. R. J. Baldock, R. Fernandes, and M. Fitzharris, “The relationship between Motorcycle Rider Behaviour Questionnaire scores and crashes for riders in Australia,” *Accid. Anal. Prev.*, vol. 102, pp. 202–212, 2017.
12. J. B. Schreiber, A. Nora, F. K. Stage, and E. A. Barlow, “Reporting Structural Equation Modeling and Confirmatory Factor Analysis Results: A Review.”

AUTHORS PROFILE

N H Mokhtar obtained her Bachelor in Mechanical Engineering from Shibaura Institute of Technology in Japan, Master in Mechanical Engineering from Universiti Teknologi Malaysia and PhD in Mechanical Engineering (System Integration) from Yokohama National University.

Mukhtar M F received his Bachelors in Mathematics Education and Masters in Science (Mathematics) from Universiti Teknologi Malaysia in 2010 and 2011 respectively. He is a Lecturer at Universiti Teknikal Malaysia Melaka, Malaysia. His field of specialization are Stochastic and Social Science Studies

Luqman Hamzah graduated from University of Minnesota in Bachelor of Mechanical Engineering (2005). He is a Chartered Engineer and a member of Institution of Mechanical Engineers (IMechE).

This author is very knowledgeable in Automotive Industry especially in Research and Development and Automotive Testing with 10 years of experience working for PERODUA Manufacturing Sdn. Bhd, RND department. His previous work includes part evaluation and certification, strain measurement and life time estimation; and destructive testing.

Husni C. Mamat graduated from UiTM in Bachelor (Hons.) Mechanical of Engineering. He was a former Product Engineer at Adient Sdn. Bhd (formerly known as Johnson Controls Automotive Seating Sdn Bhd). He has 5 years of working experience in the industry of automotive specialized in Seating configuration development.

M M Zamberi received her Bachelors in Mechanical Engineering from Universiti Teknikal Malaysia Melaka in 2005. In 2008, she receive her Masters in Mechanical Engineering from The University of Leeds. She is a Lecturer at Universiti Teknikal Malaysia Melaka, Malaysia.