



Preferential factors and usability effects on vehicle modifications for the Malaysian independent disabled driver

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Abstract

The usability of driving modifications for a person with disabilities is known to be an important aspect in addressing the independent vehicle's driving capabilities. The existence of assistive modifications such as hand control, secondary control, foot control, and also the wheelchair assisted vehicle, which were developed to accommodate limitations were found to be widely used. A survey was conducted on 202 Malaysian independent disabled drivers from Kuala Lumpur, Selangor, Perak, Johor Baharu, Terengganu, and also Melaka. The components evaluated in the survey include the origin of modification used for driving, factors influencing the decision on the type of vehicle modification, usability difficulties when modification is in use, the satisfaction level of product appearance, as well as to understand user preferences when making decisions between modifications. A Likert scale of 1 to 5 was used as measurement, in order to rate the score given by the responses for each question in the survey. As a result, it was discovered that aspects such as the modification colour, shape, the toggle, pedal grip, regulation, modification availability, and movement limitation on the involved body part are among the major factors influencing the driver to make modification for driving purposes. Major factors were also found to influence the driving modification preferences to suit the category of disabilities. It was also discovered that components such as the availability of modification information and emergency driving situations are some of the least important factors influencing the decision to make and select a suitable driving modification. However, these less important components must not be ignored as it also contributes to the improvement for independent disabled driving, and also for the purpose of assistive product development.

Keywords: *person with disabilities; disabled vehicle modification; modification preferences; difficulties of use; and preferential factors.*

1. Introduction

The importance of owning a modified vehicle, particularly for a person with disabilities, is undeniable. It is regarded as a necessity as most actions, from entering, sitting, accelerating, decelerating a vehicle, changing lane, and also manoeuvring a vehicle, would require assistance. The situation was proven in the observations from a study on accelerating and decelerating a vehicle on 10 disabled drivers [1]. Its results showed that the user will require more muscle action due to the additional weight of the installed modifications. In addition, the modifications evaluated in the study required the user to use their hand to handle different controls. It is also found that a disabled person's body position will become unstable due to multiple movements when driving a modified vehicle. As a result, the actions lead to disrupted concentration while driving and the possibility of collisions.

The speed and also the level of awareness for the different disabilities such as between right and left body part are not similar. This situation was proven in a study on 20 left and right hemiplegia sufferers who were given three types of foot control modifications to test [2]. As a result, the response and movement time for people who suffer left hemiplegia are faster compared to a person with right hemiplegia.

Certain actions also led to injuries and pain when being performed without any assistance from either assistive technology, or from a

person. This problem was found in an observational study on wheelchair users [paraplegic driver] when entering and exiting a vehicle [3]. The study showed an unmodified vehicle caused pain to occur and required longer time to complete an action. The task of entering and exiting a vehicle in this study revealed significantly high pain occurrence as the disabled person uses the car seat to lead their body to enter the vehicle.

The diversity of the act on assistive driving preferences has widely encompassed in numerous regulation. Several known regulations are standard 45-30[03] [4], and 45-60[02] [5] introduced by the Low Volume Vehicle Standard in New Zealand. In the standard, several key components were introduced and highlighted when planning for a vehicle modification. They include the design, assembly, attachment, on the road test, modification that does not require certification, and also list of recognized manufacturers. The existence of such standards is seen as working to provide parameters in ensuring the safety of the user, a person with disabilities. Apart from that, the standards also provide the user an easy step-by-step process when making vehicle modification. It is important as installing any modification with non-approved specifications may cause injuries when in use. An alarming situation was seen in a study whereby a wheelchair was used as an occupant seat in a vehicle [6]. In the study, most of the injuries involving wheelchair users were due to poor securement system to stabilize the wheelchair, sudden braking, and also improper seatbelt locking. Another study on the weakness of safety measures for people with

disabilities can be found in studies on WC19 Standard [7]. To add to this, some of the mobility aid [wheelchair] used by a person with disabilities often lack safe to use features [sharp edges and structure integrity] which could lead to injuries when involved in a collision.

The development of assistive technology, particularly on assistive driving modification, has been growing rapidly and addresses various driving limitations. The situation is evidenced by the diversity of modification categorization according to the segment such as manoeuvring, accelerating, entering, and also exiting the cars. The classification of assistive technology, particularly for the vehicle are known to be primary control, secondary control, foot control, and also vehicle accessibility [8]. However, there are also different terms used in the categorization of assistive technology whereby secondary control is called the operation of control, and primary control is known as steering control [9]. Apart from that, the development of assistive technology for disabled driving began to move to an advanced computational technology phase where a vehicle is controlled using only hand gestures [10], and also single hand driving using the Kinect-based technology [11]. Even so, the technology is still under development as it is effective only for the purpose of parking, S-shape courses, and also for non-linear steering control. In addition, the experiment is only done through digital simulation and may cause the driver to be in a dangerous situation when used on an actual road. This also the situation for driving using Kinect-based technology as it is still in the experimental stage.

Although some modifications have included elements of computational technology, there is still some of driving modification maintaining its intervention. According to a study on adaptive control performance using simulation in 2012, the portable hand control is one of the maintained modification [push and pull], less expensive, and also requires less time for installation [12]. The maintained function of the push and pull can be viewed in a study on disabled driving, where the method of use for both accelerator and brake toggle are unchanged, and changes are only seen in terms of appearance, material, size and also detachability.

Some assistive technology has been found to cause the user problems and difficulties although its existence addresses the limitation of specific body parts to facilitate control on a vehicle. One of the discoveries on the use of assistive driving was found to be the steering knob. A study on the shank, ball, fork, and knob types as modification using the finite element method showed its ability to cause bone fracture during an impact from collision [13]. The use of the steering knob as modification was also found to obstruct the airbag opening and its position [14]. Using a similar approach for analyses revealed inappropriate deployment, and incorrect positioning of the airbag on the steering wheels.

The issues addressing the limitation of usability for a person with disabilities are also given priority in Malaysia. However, focus on vehicle driving has yet to be found. This situation was proven in studies here in Malaysia which focused on building accessibility and facility through the application of specific standards such as the MS 1184:2014 [15]. Apart from that, other studies were also found focusing on providing the user with adequate accessibility [16], green design [17], and also implementation of the universal design principle [18].

A study focusing on disabled driving in Malaysia was found in 2011 [19]. A survey on the ability to drive a vehicle again, involving both motorcyclists and car users, was carried out on 90 respondents at Universiti Malaya using a general approach. The study shows that the researcher emphasized the scope of research on the aspect of usability frequency and also on difficulties that occur. It was also found that only the hand control and the foot control modifications were evaluated in the study. Apart from that, the respondents for the study were gathered from only one area, namely Universiti Malaya Medical Centre in Kuala Lumpur. The research might be biased due to the small number of respondents. Even so, the situation more or less, indicates the need for more research on disabled driving in Malaysia.

Because issues pertaining driving modification continues to rise, a survey on preferential factors and usability for the independent driver was conducted. The purpose of the study was to identify the issues on driving modification, particularly on the preferential factors and usability effects. The study was also carried out as research, particularly on disabled driving in Malaysia, are insufficient and elusive. Apart from that, design and appearance were also evaluated in this study. It is hoped that the results from this study would add value to product development, particularly for the disabled.

3. Methodology

A survey was conducted on respondents within Peninsular Malaysia from October 2016 to February 2017. The respondents were gathered from Selangor, Federal Territory of Kuala Lumpur, Federal Territory of Putrajaya, Melaka, Perak, Terengganu, and Johor Baharu. The survey used a quantitative approach. Under this approach, researchers used the snowball sampling technique to ensure the whole survey process goes smoothly [20]. The survey also involved interviews as some respondents were unable to answer the survey by themselves due to their physical condition.

The study involved a total of 202 Malaysian independent disabled drivers as respondents. A set of questionnaires consisting of respondent demographics, factors influencing the selected modification to assist driving, satisfactory level of the product appearance, and also difficulties when using the installed modification will be asked. A Likert scale of 1 to 5 will be used to evaluate the responses given by the respondents. The data from the survey will be analysed using descriptive analysis, and one-way ANOVA [analysis of variance] using SPSS software [21].

4. Results and Findings

4.1. Demographic of the Respondent

The demographics of the respondents who participated in the survey are displayed in Table 1 below. The survey was based on 202 respondents who drive independently and made vehicle modifications. The table includes the types of disabilities, types of modification made, origin of the modification, and also frequency of driving the modified vehicle. The number of males, as displayed in Table 1, made up the majority [81.7%] of respondents in the study. According to the table, 81.68% of the respondents use hand control as their driving modification. Furthermore, almost all the respondents [91.58%] were found to use their modified vehicle frequently [more than 5 times per week] to commute to any desired destination.

Figure 1 below displays the images of the assistive driving modifications made by the Malaysian independent disabled drivers. Images [a1, a2] and [b] are the modifications available in the modification record archives of relevant authorities. As for the case of images [c1, c2, c3], these two modification were found to be unavailable in the record archives of authorities. Even so, both modifications were found available and provided by only one of the approved manufacturers located in Selangor. This is because in 2013, the Road Transport Department Malaysia allowed any modification to be made to a vehicle as long as it able to address the driving limitation issues for a person with disabilities. The restriction was then waived as disability conditions for each person differed.

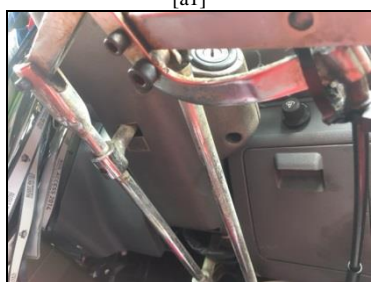
Table 1: Respondent Demographics

Demographic Variables	N [%]
Gender	
Male	165[81.7%]
Female	47[23.3%]
Occupation	
Government	5 [2.47%]
Private	32 [15.84%]
Self-employed	151 [74.75%]

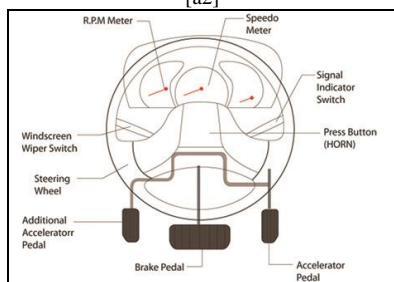
Others	14 [6.93%]
Education Level	
Postgraduate	2 [1%]
Bachelor Degree	21 [10.39%]
Diploma	54 [26.73%]
Malaysia Examination Certificate	125 [61.88%]
Types of Disabilities	
Upper body disabilities	0 [0]
Lower body disabilities	142 [70.29%]
Hand disabilities	11 [5.44%]
Leg disabilities	32 [15.84%]
Small stature	17 [8.41%]
Driving Frequencies	
More than 5 times per week	185 [91.58%]
Less than 5 times per week	17 [8.41%]
Types of Modification	
Hand control	165 [81.68%]
Secondary hand control	4 [1.98%]
Left foot control	14 [6.93%]
Wheelchair access	2 [0.99%]
Pedal extender	17 [8.41%]
Modification Origin	
Locally built	139 [68.81%]
Imported	46 [22.77%]
Custom made	17 [8.41%]



[a1]



[a2]



[b]



[c1]



[c2]



[c3]

Fig. 1: Images of vehicle modifications available for the Malaysian independent disabled driver; [a1, a2] cable type push and pull control, [b] left foot control, and [c1, c2, c3] local built detachable push and pull control.

Careful observation of the portable push and pull control [images c1, c2, and c3], it was noticed that the modification is similar to the PHC-3 and TNT portable hand control [12]. Several differences were found on the custom-built modifications of the portable hand control whereby the quality of finishing is lower compared to the PHC-3 and TNT. In addition, the custom built modifications provided by Malaysian manufacturers only used wing nuts [image d3] to tighten the modification to the accelerator and brake pedal.

4.2. Factors Influencing User's Decision to Make Vehicle Modification

Table 2 displays the mean score for the factors influencing the decision in making driving modification to a vehicle among the 202 respondents. Six factors were discovered to record a high mean score of more than 4.00. These factors are product information availability, safer driving on congested highway, modification product availability, adherence to regulations and acts, inability to drive a vehicle using standard control and also travelling distance. Recommendations by physical therapists recorded as the least important factor influencing a respondent's decision to make modifications to a vehicle for a person with disabilities.

Table 2: Factors Influencing the Decision in Making Driving Modification to a Vehicle

Influential Factors	Mean Score
Product information availability	4.66
Safer driving on congested highways	4.40
Modification product availability	4.32
Adherence to regulations and acts	4.25
Inability to drive a vehicle using the standard control	4.15
Travelling distance to desired destination/ workplace	4.07
Vehicle driving requirement by the authority	3.71
To obtain the driving license	3.37
Time duration of product installation	3.26
To receive the privilege of disabled vehicle road tax renewal price	2.98
Recommendation by physical therapist	2.93

Based on the factor variables displayed in Table 2, it was discovered that product information availability strongly influences a majority of respondents in making a decision. This situation can be seen in 148 of 202 [73.3%] respondents who strongly agree. Although to obtain a driving license and physical therapists' recommendation were positioned as two of the lowest influential factors, it should be noted that these two factors are compulsory in

helping a person with disabilities obtain a driving license. It is a standard of procedure for the disabled driving license enacted in 2012, whereby any modification to be installed in a vehicle must receive the recommendation of a physical therapist [22]. This situation also applies to a person with disabilities planning on taking a driving license. Furthermore, they must first make vehicle modifications in order to apply and take the on-road driving test.

4.3. Difficulties Faced By the Disabled Driver When Driving Using Modified Vehicle

Table 3 displays the difficulties faced by a disabled driver when driving using modifications. For the questions in this section, the flow of responses were positioned as 5 for Very Easy, 4 for Somewhat Easy, 3 for Fair, 2 for Somewhat Difficult, and 1 as Very Difficult. Due to the arrangement of the responses, the variables with the least mean score will be selected as domineer for the difficulty variables. From Table 3, three of 9 variables on usability difficulties precede the modification usability difficulties. The variables include driving in emergency situations [3.02], driving on congested roads [3.14], and also movement limitation on the body part involved [3.30]. Entering and exiting a parking space falls as the least difficult when a modification is used to perform the driving task.

Table 3: Difficulties Faced by the Disabled Driver when Driving Using Modifications

Usability Difficulties	Mean [Import]	Mean [Local Built]	Mean [Custom Built]	Mean
Driving in an emergency situation	3.59	2.47	3.00	3.02
Driving on a congested road	3.57	2.45	3.41	3.14
Movement limitation on the involved body part	3.92	2.33	3.65	3.30
Pain occurrence on the involved body part	3.94	2.35	3.65	3.31
Climbing up/ Moving Down a hilly road	3.76	2.76	3.47	3.33
Overtaking in front vehicle	3.80	2.83	3.59	3.40
Stopping/ Moving while at a road Junction	4.04	2.91	3.59	3.51
Accelerating/ Decelerating vehicle speed	3.96	2.96	3.71	3.54
Entering/ Exiting a parking space	3.91	2.97	3.82	3.56

Based on Table 3, a clear difference can be seen in the responses made by the respondent. A low mean score [less than 3.00] was recorded for each driving task with the assistance of locally built driving modification. Some of the variables with low mean score on usability difficulties can be viewed in movement limitation [2.33], and also pain occurrence in the involved body part [2.35]. Despite being displayed as the least difficult task in Table 3, both entering/exiting a parking space, and also accelerating/decelerating should not be ignored. Both tasks display quite a low mean score of 2.97 and 2.96 for locally built response modifications. This is due to the slower response when performing a task as compared to a person who is able bodied [23].

4.4. Satisfaction Level of Design and Appearance of The Modifications

Table 4 presents the responses on satisfaction level for the design and appearance of the modification. In this segment, the responses use 5 as very unsatisfied and 1 as very satisfied. From the table, 4 of the variables resulted in a high mean score where the finishing of modifications dominate the satisfaction mean score of 3.59. The high mean score then continued with the modification colour

[3.50], modification shape [3.48], and also the toggle/pedal/button grip [3.45]. The mean score for design and appearance for the finishing, colour and shape were high for locally built modifications. The mean score for locally built modification for the question on toggle/pedal/button grip also displayed a high mean score of 3.97. Again, the locally built modification prevails by becoming the modification which resulted as the least effective modification to the user due to its low satisfactory responses of mean score lower than 3.00.

Table 4: Design and Appearance Satisfactory level of Vehicle Modifications

Design and Appearance Satisfactory level	Mean Score [Import]	Mean Score [Local Built]	Mean Score [Custom Built]	Mean Score
Modification finishing	3.04	4.14	3.59	3.59
Modification colour	3.07	4.15	3.29	3.50
Modification shape	3.02	4.24	3.18	3.48
Toggle/pedal/button grip	3.04	3.97	3.35	3.45
User-friendliness	2.93	3.58	3.24	3.25
Modification position	2.91	3.12	2.88	2.97
Modification size	2.80	2.73	2.94	2.82

In terms of position and size of the used modification, most respondents cited no discomfort or distraction when in use. This was proven through an almost identical mean score of less than 3.00 for imported, locally built, and custom built modifications. Overall, imported modifications emerged as the most effective driving assistance as compared to the local and custom built modification. This can be seen in terms of the mean score for aspects such as position [2.91], size [2.80], finishing [3.04], user-friendly function [2.93], toggle/pedal/button grip [3.04], and shape [3.02] are displayed with a mean score of less than 3.05.

In the case of custom built modifications, several components within the design and appearance segments received responses with a mean score of more than 3.00. This includes the finishing [3.59], colour [3.29], toggle/pedal/button Grip [3.35], and also user-friendliness [3.24]. As a result, both custom and locally built modifications failed to meet the optimum satisfaction level among respondents. Something must be done right as both standard J1903 [24] and also J2388_201110 [25] set by the SAE, clearly emphasized on the modification design suitability, and also the modification operation effectiveness by the user.

4.5. Comparison of Preferred Modification between Types of Disabilities

Table 5 displays the significant differences on modification preferences between types of disabilities using analysis of variance. For the difference in preference, the components which displayed high mean scores from the evaluated aspect were selected and evaluated. The evaluation was done based on 4 types of disabilities comprising lower body disabilities, hand disabilities, leg disabilities, and also small stature.

In Table 5, modification colour was presented as the component with the highest significant difference of 0.03. Based on the 4 types of disabilities for this component, a significant difference of 0.012 was found between the lower body disabilities and the small statured. This significant difference can be seen as all small stature respondents gave a fair feedback for the modification colour component. As indicated by the small stature respondent, the ability to assist/reach the accelerator and the brake function are the most important aspects. The situation is different for a person with disabilities [3.96] as some indicated suitable modifications in the interior will make them feel like their disability has disappeared.

Another component in the design and appearance categories, namely the modification shape, also displayed high significant differences of 0.024. A similar situation was discovered within the components whereby there was a 0.036 mean difference between the respondent with small stature [3.12] and those with lower body disabilities [4.00]. Here, respondents with lower body disabilities

gave an average feedback stating they were somewhat dissatisfied. The situation was proven when the example of modification [image d, d2, d3], were made with poor finishing on the jointing and dull colour. These weaknesses were also emphasized in the survey study on the robotic guide for the blind person [26]. From the survey, the respondents highlighted on the design, emphasizing on appearance, size, user-friendliness, and also minimum maintenance. However, feedback received for modifications finishing among Malaysia respondents were shocking. If the mean scores between types of disabilities on the segments in Table 5 are carefully observed, the response from all four categories can be described as almost similar.

Modification availability and regulation and act in Table 5 are also variables that have significant differences between the types of disabilities. For modification availability, no significant difference existed between any types of disabilities, but low mean scores were found for responses on leg disabilities [3.91]. Even so, the other three types of disabilities recorded with mean scores above 4.00, proving that regulation and act is an important component that drives the modification preferences. The situation was found similar with modification availability as high mean scores were recorded from the entire disability category. The necessity of knowing the availability of a modification was highlighted in the interviews held with drivers suffering chronic right sided foot and ankle pain [27]. The study on 22 respondents revealed difficulties in checking the availability of suitable products. In addition, none of the physical therapists who assisted them during the rehabilitation process mentioned any car modification for assistive driving purposes. Several guidelines such as car control [28] and getting in and out of a car [29] are found to be useful references, particularly to a Malaysian with disabilities.

The category, functions, and price of the modifications can be used an overview of what modification would suit their disability conditions. The guidelines were also found to be useful for relevant Malaysian authorities or non-governmental organizations to develop their own guidelines for disabled car modification. This is one of the important issues as Malaysia does not have any proper disabled vehicle modification guidelines. To date, only two guidelines were used to assist disabled drivers here in Malaysia, known as standard of procedure on medical examination for driving license application [30] and also the department instruction No.4, year 1994 [31]. What is more distressing is that only drawings of the left accelerator pedal and the cable type push and pull control elevation are attached as reference in the appendix page.

Another variable in Table 5 which displayed significant differences was movement limitation [0.048]. Similar to modification availability and the regulation component, no significant differences were found between each type of disability. For the movement limitation component, respondents with hand disabilities recorded a mean score of 3.09 [the majority responses with fair]. As for other types of disabilities, the mean scores displayed were more than 3.40. The situation has caused results on movement limitation as the component with the most minimum significant difference. Even so, this component should not be ignored as hindrances to the movement of body parts can result in hazards and collision [32].

Table 5: Comparison of Preferred Modification between Types of Disabilities

Variables	Mean [Lower Body]	Mean [Hand]	Mean [Leg]	Mean [Small Stature]	Significance
Modification colour	3.96	3.27	3.88	3.00	0.003
Toggle/pedal/button grip	3.85	3.36	3.63	2.94	0.011
Regulation and Act	4.32	4.45	4.13	3.76	0.013
Modification product availability	4.31	4.73	3.91	4.41	0.020

Congested road driving	2.73	2.91	2.72	3.35	0.021
Modification shape	4.00	3.62	3.81	3.12	0.024
Movement limitation on the involved body part	3.44	3.09	3.94	3.82	0.048
Safer driving on congested highway	4.41	4.73	4.25	4.41	0.300
Modification finishing	3.91	3.36	3.84	3.59	0.351
Inability to drive a vehicle using the standard control	4.14	4.55	4.06	4.06	0.429
Travelling distance	4.09	4.27	3.97	4.00	0.436
Driving during emergency situation	2.74	2.82	2.78	2.94	0.770
Modification information availability	4.65	4.64	4.69	4.65	0.992

It can be seen that some of the variables in Table 5 such as safer driving, driving distance, and emergency situation driving do not have any significant difference of 0.05 or less. Indeed, all of the mentioned variables should not be ignored as they all involve the aspect of usability and product interaction with the user. Usability is also known to be important as it is a determinant and also the key to the development of new assistive products [33].

In summary, the use of the survey as an approach to evaluate the preferences of assistive driving modification and its usability effects was able to produce fast and meaningful results. As for the efficiency of opinion measurement, a respondent who uses a locally built modification is likely to give a high mean score of poor ratings. Results on preferences are different for respondents who use imported/custom built modifications. The view on the situation can be found in the result for both difficulties and design aspect. As to add more, both table design and difficulties are likely to receive low mean score from the respondent who uses imported assistive driving modification. Evaluations for this study were done using the actual product and managed to gain input on how the user will react to assistive technology. However, it is believed that conducting more studies will further benefit related parties during the preliminary stages when developing an assistive product

5. Conclusion

The results for the Preferential Factors and the Usability Effects on Assistive Driving Modifications for the Malaysian Independent Disabled Driver study have been presented. The results concluded that several important factors have the highest influence on the user. These factors include the colour, shape, availability of the modification product, regulations, and also movement limitation on the involved body part. Apart from that, variables which received high response in regards to usability difficulty such as design and appearances, which are deemed to not have any significant difference, must not be ignored.

Although some variables received less important feedback, they must be taken into account. This is important should any new development and improvements on assistive technology take place. Furthermore, the result from this survey would be highly beneficial not only the local authorities or manufacturers, but also to the related bodies outside Malaysia. It is believed that more discoveries on the user's end would add value for future development in assistive technology

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References

- [1] Ikeda H, Ikeda H, Mihoshi A, Hisari Y. Physical load related to highway driving among disabled people. *IATSS Research*. 2007;31[1]:100-9.
- [2] Pauley T, Ismail F, Boulias C, Devlin M, Phadke CP. Comparison of Foot Pedal Reaction Time Among Patients with Right or Left Hemiplegia and Able-Bodied Controls. *Topics in Stroke Rehabilitation*. 2013;20[6]:500-8.
- [3] Haubert LL, Mulroy SJ, Hatchett PE, Eberly VJ, Maneekobkunwong S, Gronley JK, et al. Car transfer and wheelchair loading techniques in independent drivers with paraplegia. *Frontiers in Bioengineering and Biotechnology*. 2015;3:2-7.
- [4] Incorporated LVVTA. Disability Adaptive Control Systems. New Zealand: Low Volume Vehicle Technical Association Incorporated; 2010. p. 1-25.
- [5] Standard LVV. [Disability Transportation Systems]. New Zealand: Low Volume Vehicle Standard 2016. p. 1-49.
- [6] Buning ME, Bertocci G, Schneider LW, Manary M, Karg P, Brown D, et al. RESNA's Position on Wheelchairs Used as Seats in Motor Vehicles. *Assistive Technology*. 2012;24:132-41.
- [7] Manary MA, Ritchie NL, Schneider LW. WC19: A wheelchair transportation safety standard—Experience to date and future directions. *Medical Engineering & Physics*. 2010;32:263-71.
- [8] Roosmalen Lv, Paquin GJ, Steinfeld AM. Quality of Life Technology: The State of Personal Transportation. *Physical Rehabilitation and Medical Clinics*. 2010;21[1]:11-25.
- [9] Monacelli E, Dupin F, Dumas C, Wagstaff P. A review of the current situation and some future developments to aid disabled and senior drivers in France. *Alliance for engineering in Biology and Medicine*. 2009;30:234-9.
- [10] Murata Y, Yoshida K. Automobile Driving Interface Using Gesture Operations for Disabled People. *International Journal on Advances in Intelligent Systems*. 2013;6[3&4]:329-41.
- [11] Son JP, Sowmya A. Single-Handed Driving System with Kinect. *Human-Computer Interaction*. 2013:631-9.
- [12] Boyce MW, Fekety Dk, Smither JA. Resource Consumption and Simulator Driving Performance Using Adaptive Controls. *Assistive Technology*. 2013;25:158-65.
- [13] Sanchez-Caballero S, Selles MA, Sanz AVM, Olcina MJ. Risk assessment of driving adaptations for disabled people. The 6th edition of the Interdisciplinarity in Engineering International Conference "Petru Maior"; University of Tirgu Mures, Romania 2012.
- [14] Maisa J, Eixeres B, Dols J, editors. Models for airbag simulation in vehicles adapted for disabled driver. 12th international congress on project engineering 2008; zarragoza
- [15] Bashiti A, Rahim AA. Physical Barriers Faced by People with Disabilities [PwDs] in Shopping Malls. *Procedia - Social and Behavioral Sciences*. 2016;222:414-22.
- [16] Kadir SA, Jamaludin M. Applicability of Malaysian Standards and Universal Design in Public Buildings in Putrajaya. *Procedia - Social and Behavioral Sciences*. 2012;36:659 - 69.
- [17] Yiing CF, Yaacob NM, Hussein H. Achieving Sustainable Development: Accessibility of Green Buildings in Malaysia. *Procedia - Social and Behavioral Sciences*. 2013;101:120-9.
- [18] Sahamir SR, Zakaria R. Green Assessment Criteria for Public Hospital Building Development in Malaysia. *Procedia Environmental Sciences*. 2014;20:106-15.
- [19] Engkasan JP, Ehsan FM, Chung TY. Ability to return to driving after major lower limb amputation. *Journal Rehabilitation Medicine*. 2011;44:20-3.
- [20] Browne K. Snowball sampling: using social networks to research non-heterosexual women. *International Journal of Social Research Methodology* 2005;8[1]:47-60.
- [21] Aldrich JO, Cunningham JB. Using IBM SPSS Statistic: Second Edition. Knight V, editor. California Sage Publication; 2016. 439 p.
- [22] Malaysia RTD. Form Use and Medical Examination Standards for the Disabled Driving License Application at Malaysia Ministry of Health Facility. Road Transport Department; 2012. p. 8.
- [23] Stern EB, Davis ES, Durfee WK, Rosenthal TJ, Wachtel J. Discriminating between brain injured and non-disabled persons: a PC-based interactive driving simulator pilot project *Advances in Transportation Studies an international Journal* 2004;Special Issue.
- [24] Committee ADS. Automotive Adaptive Driver Controls, Manual. SAE International; 2010.
- [25] Committee ADS. Secondary Control Modifications. SAE International; 2011.
- [26] Hersh MA, Johnson MA. A Robotic Guide for Blind People. Part 1. A Multi-National Survey of the Attitudes, Requirements and Preferences of Potential End-Users. *Applied Bionics and Biomechanics*. 2010;7[4]: 277-88.
- [27] Jones C, Abbassian A, Trompeter A, Solan M. Driving a modified car: A simple but unexploited adjunct in the management of patients with chronic right sided foot and ankle pain. *Foot and ankle surgery* 2010;16[4]:170-3.
- [28] Holmes J. Car controls: A guide for older and disabled people. In: Research Institute of Consumer affair R, editor.: Ricability; 2012.
- [29] Cassie Barton, Holmes J. Getting in and out of a car. In: Research Institute of Consumer Affairs R, editor. London: Rica; 2013.
- [30] Medical Examination Standards for Disabled Driving License at Malaysia Ministry of Health Facility, [2012].
- [31] Department RT. Department Instruction No. 4, Year 1994. Kuala Lumpur, Malaysia: Road Transport Department 1994.
- [32] Várhelyi A, Kaufmann C, Persson A. User-related assessment of a Driver Assistance System for Continuous Support – A field trial. *Transportation Research Part F: Traffic Psychology and Behaviour*. 2015;30:128-44.
- [33] Choi YM, Sprigle SH. Approaches for Evaluating the Usability of Assistive Technology Product Prototypes. *Assistive Technology*. 2011;23:36-41.