AENSI Journals

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Virtual Reality Framework Development in Malaysian Automotive Manufacturing Industry

[1]Maryam Mousavi, [1]Faieza Abdul Aziz, [1]Napsiah Ismail and [2]Shahryar Sorooshian

[1]*Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.*
[2]*Faculty of Technology, University Malaysia Pahang, Malaysia*

ARTICLE INFO

Article history:
Received 17 October 2013
Received in revised form 21 November 2013
Accepted 22 November 2013
Available online 26 December 2013

Key words:
automotive industry, Malaysia

ABSTRACT

Virtual reality (VR) provides a new opportunity to improve productivity and enhance quality of manufacturing. Malaysian automotive industry also adopted VR and three-dimensional (3D) modelling at different stages. It is always difficult to choose the right technology at the right time and at the right place. There is no clear guideline among automotive companies about technological causes behind their success and failure. Most of the time, automotive industry is confused to decide which technology is most appropriate for their technology-based industrialisation and improvement. Six car companies in Malaysia have been chosen for this study. Forty questionnaires were randomly distributed at each company. More than 62% of the questionnaires received from the respondents. To analyse respondents' answers, t-Test and Pearson chi-square test were conducted followed by frequency analysis and a conceptual method has also been used for developing a framework. This research provides a framework for automotive industry adoption with VR technology. This framework recommends the VR technology adoption to the industry based on its remarkable points in each segments of the industry. The framework will help policy makers, managers, designers, engineers, and researchers to make their decision more easily and efficiently for VR technology implementation. Results of framework implementation have also been described in the results section of the paper.

To Cite This Article: Maryam Mousavi, Faieza Abdul Aziz, Napsiah Ismail and Shahryar Sorooshian., Virtual Reality Framework Development in Malaysian Automotive Manufacturing Industry. ***Aust. J. Basic & Appl. Sci.,*** *7(13): 139-146, 2013*

INTRODUCTION

Automotive Industry in Malaysia:

Automotive industry in Malaysia can be considered as one of the most important and strategic industries in manufacturing sector. Launching of the National Car Project, Perusahaan Automobil Nasional (PROTON) in 1984 was one stage of the development in the Malaysian automotive industry (Rosli, 2006). Second national car company (PERODUA) was started in 1992 (Arshad, 2001). Proton and Perodua are the main national automotive industry in Malaysia. They sold almost 90% of total vehicle annually (OICA, 2011). Although the two national producers still dominate the competitive landscape in terms of combined market share, major producers such as Toyota and Honda are close behind (Report Q1, 2009). As a whole, Malaysian automotive industry after an upward production trend until 2005 faced two years of production decrease, although in 2008 they could boost up their production level.

Academic and Research Based Framework:

Researchers have different definitions about framework. Yusof and Aspinwall (2000) describe frameworks through diagrams, flowcharts, and graphical or pictorial representations. Popper and Notturno (1996) define a framework as a set of fundamental principles, which can help to promote discussions and actions. Many researchers, mainly through their own research, knowledge and experience developed the academic based frameworks related to automotive industry that some of them are presented in following.

Nashashibi (2000) designed a framework to be specifically used in the prototyping phase of multi-sensor automotive applications. Due to the importance of privacy technology, which enables users and service providers to define flexible data model and policy models, Duri *et al*. (2002) have developed a framework for security and privacy in automotive telematics. Further studies on automotive industry led to development of a

Corresponding Author: Maryam Mousavi, Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
E-mail: mousavi.maryam@gmail.com

conceptual framework proposed by Boujut and Laureillard (2002) for the improvement in engineering design cooperation within the design organisations.

In line with other researchers in order to provide a systematic plans for every aspect of the manufacturing industry, Deros *et al*. (2006) have presented a conceptual framework for benchmarking implementation in Small Medium-sized Enterprises (SMEs) considering their characteristics. In the designing section of the manufacturing industry, Park *et al*. (2006) developed an e-Engineering framework for automotive module design with focus on the initial prototype design stage of automotive suspension module. In addition, a framework for automotive design was developed based on the computer-aided intelligent system that can automatically generate the optimal joint types and assembly sequences for the best dimensional quality (Chen, 2006). Kokai *et al*. (2007) have also presented a framework for an integrated 2D-3D design environment, in which the core of the framework is a model representing the characteristic lines of automotive shapes built from a set of example shapes. Based on SMEs in the Malaysian automobile industry a general framework is developed by Osman *et al*. (2009) for automobile industry to improve services to the customer. Overall, Many frameworks have been developed in automotive industry so far, but there is no guideline or framework about applying VR in automotive industry. Therefore, this study is focused on reducing this technological gap and provides a VR adoption framework in automotive industry

MATERIALS AND METHODS

2.1. Subjects:

After reviewing information regarding automotive manufacturing industry in Malaysia, six car companies were selected as the main source of data for this research. Mainly two major types of data were collected in this research; (1) field data, and (2) Secondary data from different sources such as databases, books, websites, etc. This survey employed two data collection methods; (1) Survey interviews, and (2) Focus group interviews (Mousavi, 2011). Questionnaire was the way chosen for performing the survey interviews. Forty questionnaires randomly were distributed among the employers of each company. As Fraenkel and Wallen (2000) mentioned, in order to following the normal distribution and random selection characteristic, the number of the respondents selected in survey interviews using questionnaire should be above 30.

Four groups including five people classified for focus group interview, namely manufacturing, designing, 'planning and research', and engineering. As focus group interview considered as purposive sampling (Miles and Huberman, 1984), the proper number of participants for a successful focus group should consist of 4 to 12 people (Brown, 1999). The researcher by herself represented respondents to have more communication with them.

2.2. Questionnaire design:

The review of the literature, regarding the preparation of the questionnaire to comprise all aspects of the research objectives, has led to a structured questionnaire with three main parts (Singh, 2002; Esposito, 2002). Each part is collecting various information from the respondents that definition and explanation of each section of the questionnaire is discussed as,

Section A: Primary information of respondents

Section B: Technology adoption

Section C: 3D and VR uses in the industry

Section A was demographic information of respondents such as; sex, age, experience, responsibility, and education. Section B was about technology adoption. The respondents were asked regarding sufficiency of the existing technologies at their organisation, which part needs to be improved regarding the technology, appropriateness of VR for adopting to the departments, preference of using software(s) with better features, etc. Section C took into account questions regarding the system they are using, usage of 3D modelling and VR technology, percentage of their total projects utilises 3D and VR, Stage(s) and activities in the projects that they use 3D and VR. Reasons, barriers and benefits of using 3D and VR in their company and cost efficiency of them.

After designing the questionnaire, it has been reviewed by two statisticians from UPM and Booalisina University of Iran. Next, to assure that questionnaire is clear and understandable it has been distributed among some related automotive industry responsibilities and necessary changes have been done.

2.3. Statistical Analysis:

T-Test and Pearson chi-square test are two statistical data analysis tools based on hypothesis testing which are commonly used in this area of discourse (Migaldi *et al*., 2004; MacLaughlin *et al*., 2004; Chan *et al*., 2010).

In this study, these two tests are used to test the significant association between (1) the average use of 3D and VR technology, (2) sufficiency of existing technology and need of use software with better features, (3)

association between four departments of car companies and adopting to the technology. Probability value used for the testes here is 0.05.

2.4. Framework Development:

How one can characterise a suitable framework that really can help the automotive industry for VR adoption? In general, some criteria should be considered in developing a good framework such as, being systematic and easily understandable, simple in structure, clearly linked between the elements, and implementable (Yusof and Aspinwall, 2000). Overall, the framework development consists of four sequential steps (refer to Figure 1) as below,

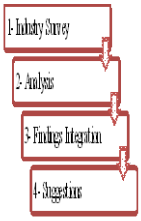

Fig. 1: Framework Development Process

In the first place, the designed questionnaire is utilised to survey the industry practitioners' comments about VR applications, software, systems, barriers, and benefits gained. Some of the major aspects in VR adoption process drew out form the analysis of the questionnaires, which led to better understanding of the VR state of the art in Malaysian automotive industry. In findings integration step, interconnections between the several aspects of VR adoption such as preparation activities, specification requirements in VR adoption, suitable areas for implementation VR, and possible benefits defined. At the end step, the results of the analyses in every part presented in the form of suggestions to simplify the process of technology selection for the industry decision makers (Deros *et al*., 2006).

2.4.1. Framework Implementation and Validation:

In order to verify the developed framework, another set of questionnaire is designed to assess the framework's strength and weaknesses based on the industry responses. The newly defined questionnaire is distributed among the all six companies. The framework validation process follows the validation method of benchmarking implementation framework developed by Deros *et al*. (2006) and guidelines given by Esposito (2002). The questionnaire is designed mainly based on the following key factors to assess,

- framework feasibility,
- understandability,
- implementation,
- coverage of the major aspects, and
- straightforward guidance to implement VR.

RESULTS AND DISCUSSION

Demographic Profile of Respondents

After analysing the demographic part of the questionnaires, answers are indicated in the Table 1.

Table 1: Respondents Demographic Profile

Variable	Percentage
Gender	
Male	69.9
Female	30.1
Age	
20-29	41.2
30-39	45.1
40-50	11.1
Above 50	2.6
Educational level	
College/diploma	7.8
University	92.2
Responsibility	
Executive	52.3
Engineering management	12.4
Manufacturing designer	12.4

Software engineer	10.5
Work experience	
less than 1 year	7.8
More than 1 year and Less than 3 years	20.3
More than 3 years and Less than 5 years	25.5
5-10 years	30.1
More than 10 years	16.3

3.2. Results of analysis:

After doing statistical analysis on the questionnaire by using t-test and pearson chi square, many results obtained such as; (1) companies are in need of adoption to the new technology and existing technology are not sufficient, (2) four departments, namely designing, manufacturing, 'planning and research' and engineering need to be adopted with new technology. Analysing the respondents' comments about different aspects of VR application helped for better understanding of the VR application state of affairs in Malaysian automotive industry. The analysis of the questionnaire highlighted some important points in VR application that are used in preparation of the framework details. The important aspects in VR application are considered in the development of framework that shows the strategy and scope of VR adoption project. For instance, the required preparation activities, software and hardware selection criteria, and potential areas for VR adoption are discussed and embedded in the framework building. Resultant of all the descriptive and statistical analyses done on the responses received from the industry used to design a framework for the VR adoption in Malaysian automotive industry.

3.3. The Virtual Reality Framework Development:

According to the methodology explained in section 2.4 for framework development, the first two steps of framework development procedure, industry survey and analysis of the responses, are already accomplished (refer to Figure 1). To complete the third step of the framework preparation, interconnections between the obtained aspects in VR application are demonstrated in the developed framework. This work provides a comprehensive picture of VR adoption process as well as a step-by-step guideline for VR adoption. The last part of the framework development process provides some suggestions to simplify the technology selection process. Therefore, based on the analysis of the results, author recommendations are provided in the framework building, which users may be benefited from them in terms of saving time and investment in VR adoption. A general schematic of the developed framework is shown in Figure 2 and the details of the framework is shown in Figure 3. The general schematic consists of five phases to show VR adoption process. Each of the phases is discussed in details in the following paragraphs.

Phase one explains the preparation activities required for VR adoption. The preparation for VR implementation should be done with respect to certain parameters such as hardware and systems, software, skilled manpower, and timing. It should be noted that the initial investment is one of the constraints that industry may face it for any new technology adoption even if the adoption is cost effective.

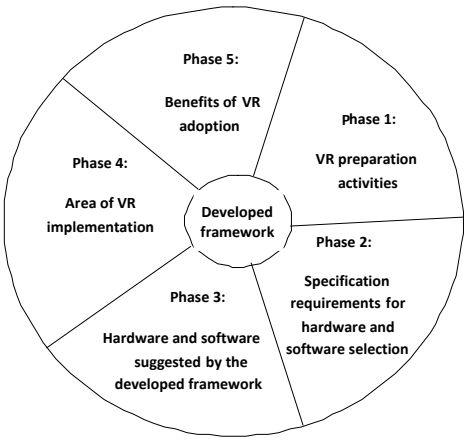

Fig. 2: A General Schematic of the Developed Framework for VR Adoption in Automotive Industry

Besides, the skilled manpower is needed for the new technology adoption for the system control and software management. The maintenance and control of the system and software must be considered in every technology adoption. It is strongly supported by the industry practitioners that having enough skilled manpower plays a key role in VR technology adoption. Therefore, it is recommended to take into account, training of personnel for the new technology adoption. In addition, a point should be noted that the adoption of new

technology usually takes time in each of its steps to be implemented, and it should be considered in the anticipated project time.

Hardware and software cost in VR adoption are two of the important options should be considered by the decision makers. Moreover, these two items are basic needs in VR adoption, which should be prepared for the technology adoption. It is required to have a complete knowledge of the available options of hardware and software and choose the right one. The selection of the appropriate software and system has always been an important point in the application of any technology.

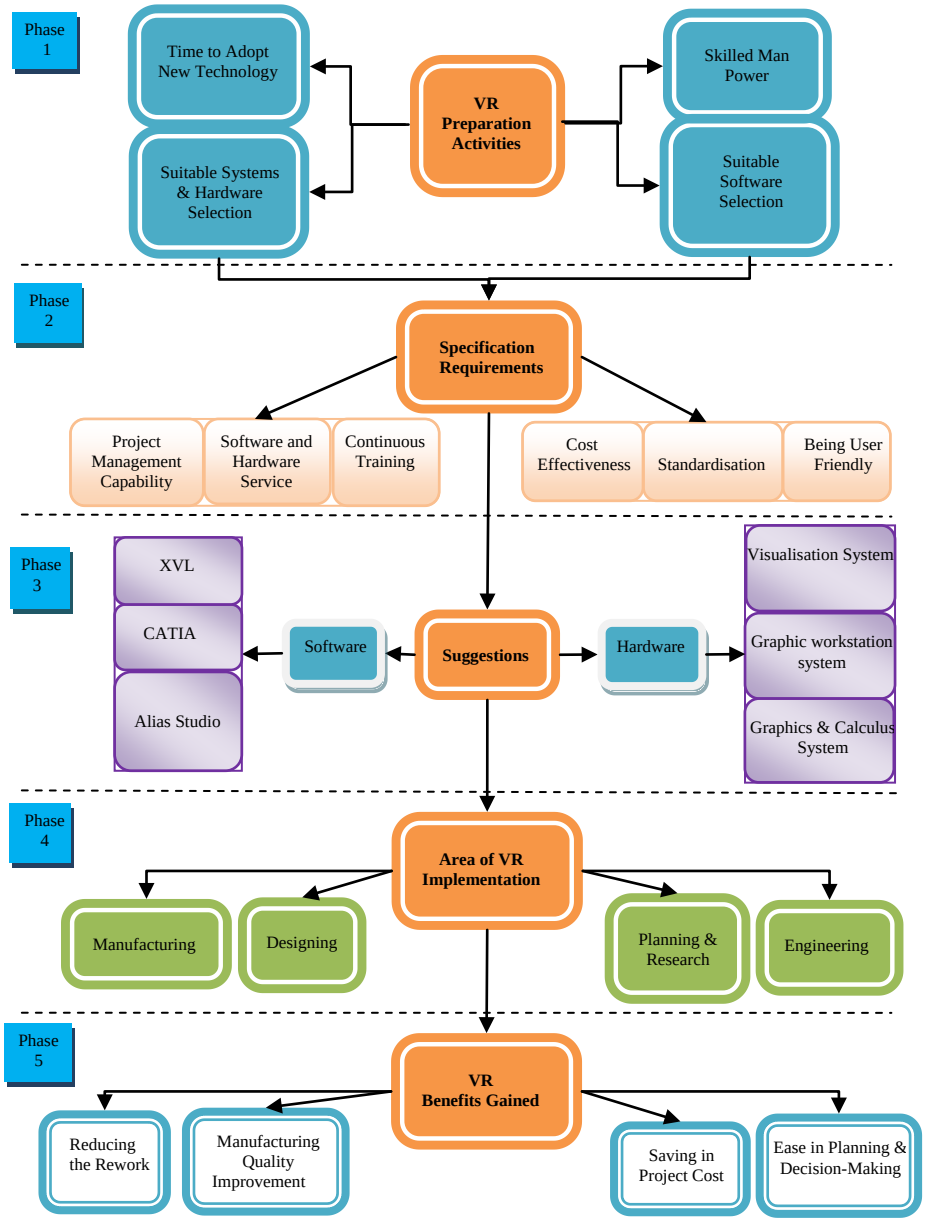

Fig. 3: Framework of Adopting VR in Automotive Industry

It is too easy to be buried in the details when a decision maker is dealing with complex sets of requirements and capabilities of software and systems. The second phase of the framework, according to the survey results, for the software, hardware and systems selection is providing some important factors to be considered. Being user friendly, having high project management capability, cost effectiveness, and standardisation together with supported training and service by the supplier of the software and system are important specifications that suggested to be noticed for the software and system selection.

Due to the variety of software in VR technology and relying on the stated specification requirements for the selection of systems and software, the author suggests some of the more beneficial and applicable software and systems to the users of the framework in the third phase. Among the available VR systems, ‘Visualisation

system', 'Graphic workstation system', and 'Graphic and calculus system' are suggested. Moreover, XVL, CATIA, and ALIAS Studio software are the recommended software. The above software and systems are recommended based on the analysis of their usage in the industry and defined specifications in phase two.

It is important to know which section needs to be adopted to VR technology to help the industry most effectively and efficiently to achieve the company objectives and strategies. The framework introduces some potential area of implementation for VR technology that are statistically proved to be in need of adoption with new technology (phase four). The descriptive and statistical analysis of the industry responses reveals that manufacturing, designing, 'planning and research', and engineering sections of the car manufacturing industry are required to be adopted with the new technology.

The possible advantages of the application of VR technology in the selected area of interest are presented in the last phase of the framework. The remarkable benefits gained from VR adoption in automotive industry are 'reducing the rework', 'manufacturing quality improvement', 'ease in planning and decision making' ,and 'saving the project expenditure'. With respect to these highlighted points of VR application, it can be a worthwhile alternative to the existing technology in automotive industry. Briefly, the author recommends the VR technology adoption to the automotive industry.

In general, the framework systematically familiarise users with the preparation activities for VR adoption. They are provided by some recommendations in order to select suitable systems and software for their technology adoption. This can help to avoid considering many possible characteristics of software and systems and focus on the significant required specifications. In completion of software and system selection process, the framework suggests more beneficial software and systems to the users. Potential areas of VR implementation in automotive industry are introduced to be considered for VR adoption. In the last part of the framework, possible benefits from VR adoption are presented that may help decision makers in the selection and implementation of VR by introducing the future benefits of VR application in their industry.

3.4. Implementation and Validation of the Framework:

The proposed framework for VR adoption was validated using a survey on its implementation capabilities among the industry practitioners in the studied car manufacturing companies. In this section, the author discusses general and specific comments made by respondents concerning the framework's strengths and weaknesses. Overall, the industry respondents' comments on every aspect and general view of the framework are gathered. For this purpose, the framework, its description and set of questionnaires have been distributed among the respondents. An instruction about the implementation of the framework has been provided to them.

The proposed framework received positive comments from all the six companies. According to the questionnaire analysis and Figure 4, the respondents have been agreed that the framework is applicable, easily understandable, covers all the major aspects of VR adoption process, and it provides a straightforward guidance. It is agreed that the highlighted requirements in selection of software and systems are well defined to cover all the necessary features of VR software and systems. They strongly agreed that the suggested software and systems are suitable options to be considered in VR adoption. It is also agreed that the introduced areas of VR implementation cover all the potential areas for VR adoption. In addition, respondents stated that the considered benefits of VR adoption are feasible.

A total number of 36 questionnaires have been distributed among the companies and 27 respondents have replied to the survey. As discussed earlier, majority of respondents had positive viewpoint about the framework. Figure 4 demonstrates the percentages of agreement among the respondents toward the questions being asked regarding the framework. There is a common agreement (97%) that the framework is straightforward to be used for either beginners or experts in VR concept. Although 87% of the respondents have been agreed that the specified requirements for software and hardware selection are well defined, it is also mentioned that the maintenance and accessibility of them should be considered in the framework. The recommendations for selection of hardware and software are marked suitable by 92% and 96% of respondents respectively. Polywork software has been suggested by one of the respondent to be added to the recommended software although the others supported the introduced softwares in the framework.

It was intended to provide a straightforward framework to shorten the process of VR adoption in an overall view. Eventually, the comments received showed that the framework gave sufficient information about the important VR adoption requirements and recommendations, which can be helpful for VR adoption.

Conclusion:

The developed framework drawn of this research based on its remarkable points in each segments of the industry recommends required specifications, suitable software selection, and suitable 'systems and hardware' selection. The framework discusses VR preparation activities, area of VR implementation and VR benefits gained. The framework can help the manufacturers and decision makers to conveniently decide on what they should consider for adopting the advance technology, VR, in their respective industry. The proposed framework received positive comments from all the six companies after a survey for its implementation. It is supported by

the respondents that the framework is straightforward to be used for either beginners or experts in VR concept. It is easy to understand and it is applicable.

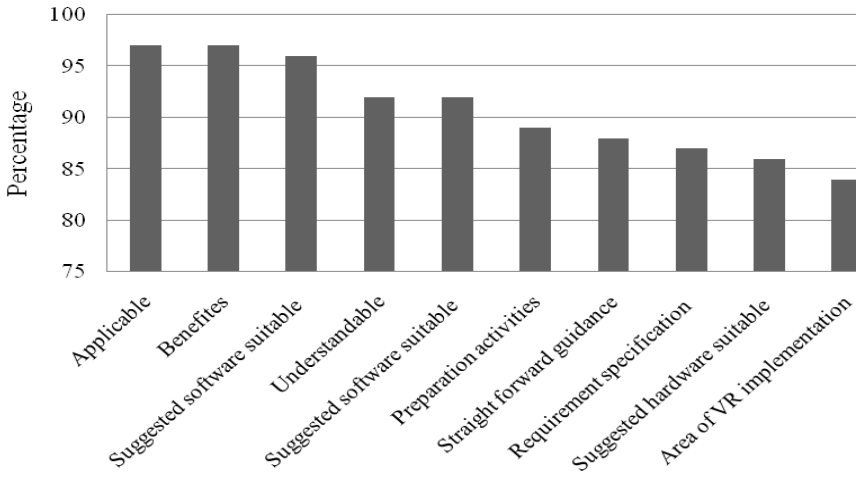

Fig. 4: Framework Validation Results

REFERENCES

Arshad, S.I., 2001. V. MALAYSIA. A. Director. Kuala Lumpur.

Boujut, J. and P. Laureillard, 2002. "A co-operation framework for product–process integration in engineering design." Design studies, 23(6): 497-513.

Deros, B., S. Yusof, *et al*., 2006. "A benchmarking implementation framework for automotive manufacturing SMEs." Benchmarking: An International Journal., 13(4): 396-430.

Osman, I., H. Ali, *et al*., 2009. "Total quality Management in the Malaysian Automobile Industry." International Business Research, 2(1): 203-208.

Popper, K. and M. Notturno, 1996. The myth of the framework: In defence of science and rationality, Routledge.

Report, A., 2009. Malaysia Autos Report Q1 2009. Part of BMI's Industry Report & Forecasts Series.

Rosli, M., 2006. "The Automobile Industry and Performance of Malaysian Auto Production." Journal of Economic Cooperation, 27(1): 89-114.

Yusof, S. and E. Aspinwall, 2000. "A conceptual framework for TQM implementation for SMEs." The TQM Magazine, 12(1): 31-37.

Boujut, J., P. Laureillard, 2002. "A co-operation framework for product–process integration in engineering design." Design studies, 23(6): 497-513.

Broll, W., 1997. Distributed virtual reality for everyone-a Framework for networked VR on the Internet Proc. IEEE Virtual Reality Ann. Int. Symp. (VRAIS'97) (Albuquerque, NM, March 1-5.

Brown, J.B., 1999. The use of focus groups in clinical research, in Doing qualitative research, 2nd edn, edited by Crabtree B F & Miller William L (Thousand Oaks, Sage).109-124.

Chan DWM, Chan APC, Choi TNY., 2010. An empirical survey of the benefits of implementing pay for safety scheme (PFSS) in the Hong Kong construction industry, Journal of Safety Research, 41(5): 433-443.

Chen, G., J. Zhou, W. Cai, X. Lai, Z. Lin, R. Menassa, 2006. A framework for an automotive body assembly process design system, Computer-Aided Design, 38(5): 531-539.

Deros, B., S. Yusof, *et al*., 2006. "A benchmarking implementation framework for automotive manufacturing SMEs." Benchmarking: An International Journal., 13(4): 396-430.

Duri, S., M. Gruteser, X. Liu, P. Moskowitz, R. Perez, M. Singh, J.M. Tang, 2002. Framework for security and privacy in automotive telematics, Proceedings of the 2nd international workshop on Mobile commerce, September 28-28, Atlanta, Georgia, USA.

Esposito, J.L., 2002. A Framework Relating Questionnaire Design and Evaluation Processes to Sources of Measurement Error. Paper presented at International Conference on Questionnaire Development, Evaluation, and Testing Methods, Charleston, SC.

Fraenkel, J.R., N.E. Wallen, 2000. How to design and evaluate research in education (4 ed.). New York: McGraw-Hill.

Kokai, I., J. Finger, R. Smith, R. Pawlicki, T. Vetter, 2007. Example-Based Conceptual Styling Framework for Automobile Shapes, Proc. Fourth Eurographics Workshop on Sketch-Based Interfaces and Modeling.

MacLaughlin, E.J., R.B. Supernaw, K.A. Howard, 2004. Impact of distance learning using video-conferencing technology on student performance, American J. Pharmaceutical Education., pp: 68(3).

Migaldi, M., G. Rossi, A. Maiorana, G. Sartori, P. Ferrari, C. De Gaetani, A. Cittadini, G.P. Trentini, A. Sgambato, 2004. Superficial papillary urothelial carcinomas in young and elderly patients: a comparative study, BJU International., 94: 311-316.

Miles, M.B., A.M. Huberman, 1984. Qualitative data analysis: a sourcebook of new methods (Sage Publications, Beverly Hills).

Nashashibi, F., 2000. A framework for prototyping automotive multi-sensor applications. In: IEEE Intelligent Vehicles Symposium Proc., Dearborn (USA), pp: 99-103.

OICA, 2011. OICA is the voice speaking on automotive issues in world forums, retrieved on 9 January, 2011, from http://oica.net/category/production-statistics.

Osman, I., H. Ali, *et al*., 2009. "Total quality Management in the Malaysian Automobile Industry." International Business Research, 2(1): 203-208.

Park, S.W., J.K. Lee, J.S. Bang, B. Ch. Shin, 2006. Development of an e-Engineering Framework for Automotive Module Design, LNCS 3865, pp: 264-273.

Popper, K., M. Notturno, 1996. The myth of the framework: In defence of science and rationality, Routledge.

Report Q1, A., 2009. Malaysia Autos Report Q1 2009. Part of BMI's Industry Report & Forecasts Series.

Rosli, M., 2006. "The Automobile Industry and Performance of Malaysian Auto Production." Journal of Economic Cooperation, 27(1): 89-114.

Singh, A.K., 2002. Electronic simulation in construction, Master thesis, P.A University, India.

Tramberend, H., 1999. Avocado: A Distributed Virtual Reality Framework, Proceedings of the IEEE Virtual Reality, p: 14.

Yusof, S., E. Aspinwall, 2000. "A conceptual framework for TQM implementation for SMEs." The TQM Magazine, 12(1): 31-37.