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The Delphi hierarchy process-based study of quality engineering in Malaysia and Indonesia automotive companies

Nilda Tri Putri
Department of Industrial Engineering, Andalas University, Padang, Indonesia
Sha'ri Mohd. Yusof
Department of Manufacturing & Industrial Engineering, Universiti Teknologi Malaysia (UTM), Skudai, Malaysia, and
Dradjad Irianto
Department of Industrial Engineering, Bandung Institute of Technology, Bandung, Indonesia

Abstract

Purpose – The purpose of this paper is to empirically evaluate the critical factors for successful quality engineering (QE) implementation in automotive-related companies in Malaysia and Indonesia. The existence of these critical factors for the successful application of QE would help the automotive industries, especially in Malaysia and Indonesia, to be able to investigate their current QE practices and how they could be improved.

Design/methodology/approach – Delphic hierarchy process (DHP) methodology is used in this study. The DHP method is a combination of the Delphi method and the analytic hierarchy process (AHP) approach for determining the ranking of the factors and sub factors needed for successful QE implementation. The Delphi method is employed to gather data from automotive experts in both countries and the AHP approach is used to rank the critical factors for success of QE practices.

Findings – The findings of this study showed that the automotive industries in Malaysia and Indonesia stressed the importance of management responsibility and people management for the successful implementation of QE. Strategic quality planning, continuous improvement, and technology- and production-related resources are the most important sub factors for successful QE in both countries.

Research limitations/implications – The series of rounds that took place during the Delphi method increased the length of time required for data collection and the follow-up process. On the basis of the consideration given, the limited resources included time, financial resources, and technical availability for this study, which resulted in the small sample sizes used.

Practical implications – The ranking of the critical factors and sub factors for QE implementation could be useful for automotive-related companies in Malaysia and Indonesia to create action plans for improving their QE implementation.

Originality/value – The instrument that was developed is a contribution toward characterizing critical factors for QE. Using DHP methodology, nine factors and 31 sub factors have been validated through a series of rounds of the Delphi method. It was developed based on industry experts' inputs. Therefore, the critical factors represent actual situation for QE success.

Keywords Total quality management, Automobile industry, Quality management, Self-assessment, Quality techniques, Quality engineering, Critical factors, Delphi hierarchy process, Automotive industry

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Introduction

Over the last decade, the concepts of quality management including total quality management (TQM) and quality engineering (QE) have been widely adopted by various organizations. Hellsten and Klefsjo (2000) believe that the differences in terminology, makes the concept of quality management to be unclear and create confusion. Hassan *et al.* (2000) argue that quality management relates to soft aspects of quality, whereas QE related to the hard aspects of quality. However, both terms can overcome the same quality problem but they usually have different treatment in terms of depth and breadth. More organizations have adopted the use of QE approach as a means obtaining higher product quality and improving the level of TQM (Noviyarsi, 2005). QE implementation is, alongside critical factors, another important component of TQM, which emphasizes their importance for the improvement of TQM levels and results. Since QE is focussed on product/process design and production for customer requirement, we can define QE as the approach which consist of operational, managerial and engineering activities that a company uses for quality control (QC), quality improvement (QI), and quality assurance (QA) to achieve successful implementation of TQM (Putri and Yusof, 2009). This study attempts to provide an insight into how the implementation of these quality management concepts focussing on critical success factors (CSFs) for QE implementation in automotive industry.

To be able to increase the quality of products continuously and satisfy the customers, the automotive industries should consider adopting and implementing QE. The need for an improved understanding of the critical factors for effective and successful QE implementation is very important. Malaysia automotive industry was chosen in this study because it is one of the important industries in the manufacturing sector to make Malaysia a developed country by 2020. Since 1990, every economic sector in Malaysia has started to engage in quality management (Thiagarajan *et al.*, 2001). Meanwhile, Indonesia automotive industries which shares are more dominated by Japanese car manufacturer in which Indonesia government also hoped that Indonesia could become the basis of automotive industry in ASEAN countries. Therefore, the Indonesian government initiated various efforts to conduct QI in automotive industry. This quality concept began to be introduced by the Japanese-Indonesian joint venture company and it is wholly owned by the Japanese. For example, Astra International, this is a pioneering company that is consciously trying to develop quality culture in Indonesia by introducing quality control circle (QCC) and other TQM activities.

This study aims to rank the critical factors necessary for achieving the successful implementation of QE in the automotive industry in Indonesia and Malaysia. Toward this end, Delphic hierarchy process (DHP) methodology was employed to gather data from automotive experts in both countries and to rank the critical factors for success of QE practices. This paper presents the results of the study of critical factors for QE in Malaysia and Indonesia.

Results of this study will contribute to understanding the impact of numerous critical factors on effective QE implementation in Malaysia and Indonesia automotive industries. The existence of these CSFs for successful application of QE would help the automotive industry, especially for Malaysia and Indonesia and allow them to be able to investigate their current QE practices for improvement. While the ranking of these critical factors will help practitioners to understand the importance of these factors and later it can help them to develop an improvement plan because they probably do not have sufficient resources to handle all factors at the same time.

CSFs of QE: DHP methodology

This section presents a review of the critical factors or constructs of TQM and QE developed and utilized by researchers. Because of limited resources, it is always not feasible for organizations to devote their efforts to concurrently address all the success factors. CSFs or contributing variables or critical factors or enablers, in this study can be viewed as those things that must go right in order to ensure the successful implementation of quality management concepts such as TQM, QE, and statistical process control (SPC). The investigation of the critical factors for successful implementation of TQM, QE, and SPC has been discussed in Putri and Yusof (2009). In this research, the researcher used DHP methodology to evaluate CSFs for successful QE implementation in Malaysia and Indonesia automotive industries. The DHP is a combination of the Delphi technique and the AHP. The DHP can benefit from both a strong and widely used Delphi technique and a powerful mathematical model, the AHP (Hwang, 2004).

It is believed that the use of DHP methodology in this research is very effective for developing an evaluation model of CSFs for successful QE implementation. By using the Delphi method, the researcher strongly believed that it is a systematic procedure for eliciting and collecting experts' opinion to obtain their consensus relating to the critical factors for successful QE implementation. Meanwhile by using the AHP, the proposed critical factors achieved from Delphi method can be represented as a hierarchy and the AHP is a useful tool for prioritizing and ranking the critical factors for QE practices.

The Delphi procedure used in this study consists of three rounds of mailed survey. Results for each round was analyzed and feed back to the respondents who were asked to re-examine their opinions in light of the overall results. It is done by conducting a series of questionnaire to a panel of experts. In this research, a panel of experts were selected and chosen in their expertise on QE and automotive industry. The preliminary list of CSFs obtained from literature review was further examined by ten automotive industry experts consisting of practitioners and academics. The panel of experts served to validate the factors. The eight experts have more than six years of working experience and research in automotive industries, as well as all practitioners are working at the upper management level in automotive industry. Therefore it can be assumed that all the experts are knowledgeable about the automotive industry to represent both general practice and the opinion of the implementation of QE.

Participating in the panel of experts (formed in April 2008-May 2009) were eight QE professionals and industrialist from Malaysian and Indonesian automotive industries as shown in Table I.

Name	Position of expert	Working experience in their position (years)
B.R.W.	Head of warranty system and quality system department ADM Indonesia	3
N.W.	Department head of quality engineering ADM Indonesia	6
H.S.	Head of quality inspection department ADM Indonesia	3
H.A.	QA manager of TRW automotive electronics Sdn. Bhd. Malaysia	6
A.R.N.	Executive director of AISB Malaysia	6
I.M.D.	Director of TMMIN Company Indonesia	6
Z.O.	Chief operating officer ICSB Malaysia	3
R.J.N.	Quality assurance/QC Executive PONSB Malaysia	3

Table I. Members of the panel of industrialist experts

Two academics were also interviewed besides the eight industrialists. The academics were senior lecturers from National University of Singapore (NUS) and Bandung Institute of Technology (ITB) with sufficient knowledge on QE. They have also some experience in doing research in the automotive industry relating to quality implementation. By including academics in panel of experts, researcher can understand theoretically about QE practices and can provide insight about the weaknesses of the implementation of QE. Table II presents the sample of academics.

The first round of the Delphi technique was unstructured which enables individual experts freely to identify and describe the issues that they see as important. Semi-structured interviews were conducted with selected experts and lasting for half an hour to one and a half hours. This interview aims to collect data for round 1 Delphi method. At the time of the interview panel experts allowed to give opinions freely and explains their perception based on a set of questionnaire for round 1 of Delphi method. A set of questionnaire for round 1 was also sent via e-mail to all experts to ensure that experts are really prepared. In the last section of first round questionnaire, the panel of experts was asked to write down any comments regarding the proposed CSFs hierarchy model. After the completion of Delphi round 1, researcher sent an e-mail for rounds 2.

The second round was conducted at the end of January 2009. The nine experts from round 1 made a commitment to participate as an expert in this round. The second round of Delphi method was completed in May 2009. Based on the suggestions and comments from expert panel on the initial AHP model, adjustments and changes were made to the model. The experts agreed that the factors are critical and comprehensive, which implies that the factors are suitable for achieving effective and successful QE implementation. All of them also agreed with the revised hierarchy model of CSFs for QE implementation. At the end of the second round, there were consensus amongst the experts on the final AHP model of CSFs for successful QE implementation was obtained. It can be concluded that the obtained CSFs derived from the literature and two round of Delphi technique match with automotive industry practices and therefore suitable to be used for the last round (round 3) of Delphi technique.

Based on the findings of Delphi round 1 and round 2, generally the panel of experts agreed with the proposed AHP model for successful QE practices. One of the experts made an adjustment on the proposed AHP model by adding in new CSFs at level 2, i.e. quality technical material divided into two sub criteria at level 3: standardization quality standard and QC technical management and quality jiritsuka (independent) which consist of two sub criteria at level 3: develop management to become QC management and independence without support from mother company. By using the AHP approach, the critical factors have been divided into nine criteria and for each criterion, one can then list suitable sub criteria that need to be met in order to achieve each criterion goal. Figure 1 presents the final AHP model for QE implementation based on Delphi rounds 1 and 2.

The last round of Delphi technique known as Delphi round 3 was conducted during the months of June 2009 till May 2010. Eight of the ten experts from Delphi round 2

Name	Research interest
D.I.	Total quality management; statistical techniques; quality control; and quality tools
T.K.C	Total quality management

Table II. Members of the panel of academic experts

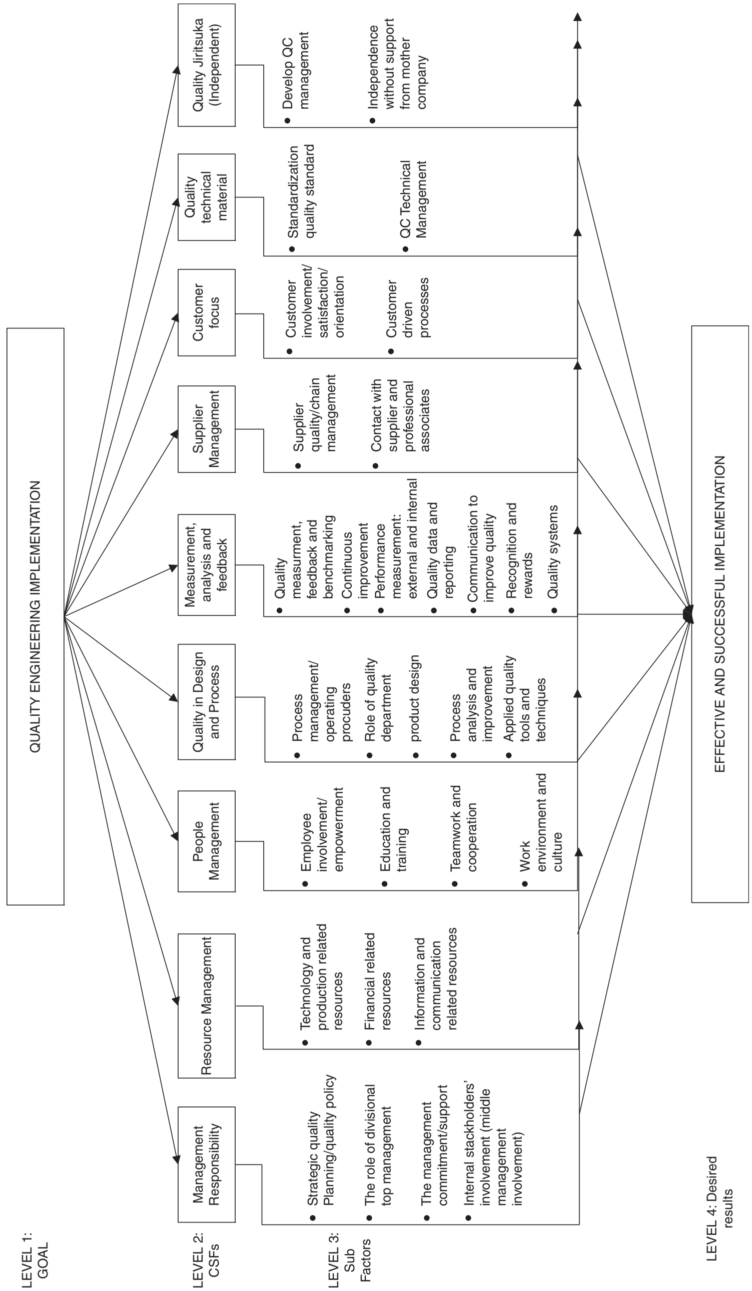

Figure 1.
The final AHP model for QE implementation based on Delphi rounds 1 and 2

returned to participate in round 3, yielding a response rate of 80 percent. They comprise of four experts from Malaysia automotive industries and also four experts from Indonesia automotive industries. They served as the evaluators to carefully determine the relative scales of a given list of critical factors and sub factors affecting their QE practices in a pair wise fashion. The pair wise comparison questionnaire for round 3 was developed by using nine-point scale. The evaluators were asked to assess a pair wise comparison among nine critical factors and related 31 sub factors with Delphi round 3 questionnaire. The evaluators would give a score for each comparison using Saaty's scale. This process continues for all levels of the hierarchy, and finally a series of judgment matrices for the critical factors and sub factors are obtained.

Having completed the Delphi third round, the importance weight or relative weights to critical factors and sub factors were calculated using AHP approach. A pair wise comparison matrix was developed to calculate "weights" which involved the relative significance among the criteria in the second level of the hierarchy. In other words, a pair wise comparison matrix is very important for determining the consistency of evaluators' preferences.

The results of this evaluation will determine the ranking of critical factors and sub factors with the aid of the multi criteria decision support analytical software known as Expert choice. The Expert choice software version 11.5 was employed to determine the normalized weights and synthesize the results. By using this software, the researcher can obtain the local and global priority weight. The local weight is the priority of an element related to its preceding element and it is first calculated. Meanwhile, the global weight of each element related to the goal of successful implementation of QE was calculated by multiplying the local weight of an element by the weight of its preceding element.

The next stage of AHP approach was to calculate a consistency ratio (CR) to measure how consistent the judgments given by panel of experts. Because the comparisons were done through personal or subjective judgments, some degree of inconsistency can occur. The results showed that the overall consistency of evaluator judgments fall within the acceptable ratio of 0.10 as suggested by Saaty (1988). This shows that the evaluators are given their weights consistently on examining the priorities of decision criteria and assessing the success of QE implementation.

After all pair wise comparisons performed at each level, and proved consistent, then the next step was to synthesize the judgments from evaluators to determine the ranking of each criteria and its sub criteria. Geometric mean approach as suggested by Saaty and Vargas (1982) was used to synthesize the assessment of each evaluator. The results from geometric mean of evaluators were combined into judgment matrices of pair wise comparison. Based on the findings, the CR for these matrices ranged from 0.00 to 0.09, which means that the results are within the acceptable level of 0.10 according to the CR recommended by Saaty (1980). This result indicates that the evaluators gave a positive outlook and assigned their weights consistently in determining the priorities of critical factors and sub factors in achieving successful implementation of QE in Malaysia and Indonesia automotive companies.

Ranking factors and sub factors

The local normalized weights of judgments

Table III summarizes the normalized local weights of judgments from the two respondent groups. The analysis comprise three parts, including Malaysian group, Indonesian group and their combined judgments.

Level	9 factors and 31 sub factors	Local weights AHP analysis by Malaysia	AHP analysis by Indonesia	AHP analysis by combined
	With respect to goal: QE implementation			
Level 2	Management responsibility (MR)	0.265	0.219	0.240
	Resource management (RM)	0.103	0.133	0.116
	People management (PM)	0.113	0.141	0.120
	Quality in design and process (QDP)	0.092	0.134	0.105
	Measurement, analysis and feedback (MAF)	0.112	0.094	0.105
	Supplier management (SM)	0.093	0.087	0.079
	Customer focus (CF)	0.076	0.083	0.100
	Quality technical material (QTM)	0.078	0.058	0.071
	Quality jiritsuka/independent (QJI)	0.067	0.051	0.064
	With respect to Management responsibility			
	Strategic quality planning (SQP)	0.381	0.509	0.448
	The role of divisional top management (RDT)	0.217	0.182	0.177
	Top management commitment (TMC)	0.221	0.183	0.183
	Internal stakeholders' involvement (ISI)	0.181	0.125	0.192
	With respect to Resource management			
	Technology and production related resources (TPR)	0.640	0.526	0.585
	Financial related resources (FRR)	0.219	0.337	0.274
	Information and communication resources (ICR)	0.141	0.138	0.14
	With respect to people management			
	Employee involvement (EINV)	0.415	0.384	0.363
	Education and training (EDT)	0.215	0.328	0.282
	Team work and cooperation (TWC)	0.223	0.163	0.212
	Work environment and culture (WEC)	0.147	0.124	0.143
	With respect to quality in design and process			
	Process management/operating procedures (PMOP)	0.282	0.270	0.248
	Role of quality department (RQD)	0.247	0.222	0.258
	Product design (PD)	0.159	0.191	0.170
	Process analysis and improvement (PAI)	0.187	0.205	0.199
	Applied quality tools and techniques (AQTT)	0.124	0.111	0.125
	With respect to measurement, analysis, and feedback			
Level 3	Quality measurement, feedback and benchmarking (QMFB)	0.188	0.233	0.214
	Continuous improvement (CI)	0.234	0.156	0.190
	Performance measurement external and internal (PMEI)	0.131	0.179	0.156
	Quality data and reporting (QDR)	0.125	0.181	0.158
	Communication to improve quality (CIQ)	0.138	0.118	0.129
	Recognition and rewards (RR)	0.103	0.065	0.073
	Quality systems (QS)	0.081	0.069	0.080
	With respect to supplier management			
	Supplier quality management (SQM)	0.837	0.794	0.817
	Contact with supplier and professional associates (CSPA)	0.163	0.206	0.183
	With respect to customer focus			
	Customer involvement (CINV)	0.738	0.798	0.770
	Customer driven processes (CDP)	0.262	0.202	0.230

(*continued*)

Table III.
Local normalized weights of judgments from panel of experts

Level	9 factors and 31 sub factors	Local weights AHP analysis by Malaysia	AHP analysis by Indonesia	AHP analysis by combined
	With respect to quality of technical material			
	Standardization quality standard (SQS)	0.827	0.749	0.791
	Quality control (QC) technical management (QCTM)	0.173	0.251	0.209
	With respect to quality jiritsuka/independent			
	Develop QC management (DQCM)	0.746	0.569	0.663
	Independence without support from mother company (ISMC)	0.254	0.431	0.337

Table III.

As summarized in Table III, it was found that both Malaysia and Indonesia group emphasized the importance of management responsibility and people management for successful QE implementation. Measurement, analysis, and feedback; resource management; and supplier management are the third, fourth, and fifth important factors respectively for Malaysia group. In the case of Indonesia group, on the other hand, quality in design and process; resource management; and measurement, analysis, and feedback are the third, fourth, and fifth important factors, respectively.

Malaysia and Indonesia group have the same opinion about the importance of the sub factors relating to several critical factors include management responsibility; resource management; quality in design and process; supplier management; customer focus; quality technical material; and quality jiritsuka/independent. However, Malaysia and Indonesia group presented different opinion about the importance of the sub factors associated with two factors, i.e. people management and measurement, analysis, and feedback.

The global weights of judgments

Table IV shows the summary of ranking from 31 sub factors based on global weights. From Table IV, the results show that three most important sub factors according to Malaysia automotive industries to achieve successful QE practices are: "strategic quality planning," "supplier quality management," and "technology and production related resources." Meanwhile "recognition and rewards," "applied quality tools and techniques," and "quality systems" were the three least important sub factors for achieving successful QE implementation.

The three critical sub factors according to Indonesia automotive industries to achieve successful QE practices are "strategic quality planning," "technology and production related resources," and "supplier quality management." Meanwhile "communication to improve quality," "recognition and rewards," and "quality systems" were the three least important sub factors for achieving successful QE implementation.

Discussions

This study provides a hierarchical model to obtain a ranking of the critical factors for achieving successful implementation of QE in the automotive industry in Malaysia and Indonesia. The instrument that was developed is a contribution toward characterizing critical factors for QE. Using DHP methodology, which is combination of Delphi and AHP techniques, nine factors and 31 sub factors have been validated through three

Table IV.
The rankings of the nine factors and 31 sub factors based on global weights

Level	AHP analysis by Malaysia group		AHP analysis by Indonesia group		AHP analysis by combined group	
	Ranking	Global weights	Ranking	Global weights	Ranking	Global weights
Level 2	1. MR	0.265	1. MR	0.219	1. MR	0.240
	2. PM	0.113	2. PM	0.141	2. PM	0.120
	3. MAF	0.112	3. QDP	0.134	3. RM	0.116
	4. RM	0.103	4. RM	0.133	4. QDP	0.105
	5. SM	0.093	5. MAF	0.094	5. MAF	0.105
	6. QDP	0.092	6. SM	0.087	6. CF	0.100
	7. QTM	0.078	7. CF	0.083	7. SM	0.079
	8. CF	0.076	8. QTM	0.058	8. QTM	0.071
	9. QJI	0.067	9. QJI	0.051	9. QJI	0.064
Level 3	1. SQP	0.101	1. SQP	0.111	1. SQP	0.108
	2. SQM	0.078	2. TPR	0.07	2. CINV	0.077
	3. TPR	0.066	3. SQM	0.069	3. TPR	0.068
	4. SQS	0.065	4. CINV	0.066	4. SQM	0.065
	5. TMC	0.059	5. EINV	0.054	5. SQS	0.056
	6. RDT	0.058	6. EDT	0.046	6. ISI	0.046
	7. CINV	0.056	7. FRR	0.045	7. TMC	0.044
	8. DQCM	0.050	8. SQS	0.044	8. RDT	0.043
	9. ISI	0.048	9. TMC	0.04	9. EINV	0.043
	10. EINV	0.047	10. RDT	0.04	10. DQCM	0.042
	11. PMOP	0.026	11. PMOP	0.036	11. EDT	0.034
	12. CI	0.026	12. RQD	0.03	12. FRR	0.032
	13. TWC	0.025	13. DQCM	0.029	13. RQD	0.027
	14. EDT	0.024	14. ISI	0.027	14. PMOP	0.026
	15. FRR	0.023	15. PAI	0.027	15. TWC	0.025
	16. RQD	0.023	16. PD	0.026	16. CDP	0.023
	17. QMFB	0.021	17. TWC	0.023	17. QMFB	0.022
	18. CDP	0.020	18. QMFB	0.022	18. PAI	0.021
	19. WEC	0.017	19. ISMC	0.022	19. ISMC	0.021
	20. PAI	0.017	20. WEC	0.018	20. CI	0.020
	21. ISMC	0.017	21. CSPA	0.018	21. PD	0.018
	22. PD	0.015	22. ICR	0.018	22. WEC	0.017
	23. PMEI	0.015	23. CDP	0.017	23. QDR	0.017
	24. CIQ	0.015	24. QDR	0.017	24. ICR	0.016
	25. CSPA	0.015	25. PMEI	0.017	25. PMEI	0.016
	26. QDR	0.014	26. CI	0.015	26. CSPA	0.015
	27. QCTM	0.014	27. QCTM	0.015	27. QCTM	0.015
	28. ICR	0.014	28. AQTT	0.015	28. AQTT	0.013
	29. RR	0.012	29. CIQ	0.011	29. CIQ	0.013
	30. AQTT	0.011	30. RR	0.006	30. RR	0.008
	31. QS	0.009	31. QS	0.006	31. QS	0.008
	27. QCTM	0.014	27. QCTM	0.015	27. QCTM	0.015
	28. ICR	0.014	28. AQTT	0.015	28. AQTT	0.013
	29. RR	0.012	29. CIQ	0.011	29. CIQ	0.013
	30. AQTT	0.011	30. RR	0.006	30. RR	0.008
	31. QS	0.009	31. QS	0.006	31. QS	0.008

rounds of the Delphi method. It was developed based on industry experts' inputs. Therefore, the critical factors represent actual situation for QE success.

This study is also aimed to examine the gap between Malaysia and Indonesia automotive industries on QE practice. Based on the current situation, comparative studies between ASEAN countries, provides an excellent opportunity that can provide overall perspective and understanding of the similarities and differences in CSFs for successful QE and in the context of Malaysia and Indonesia to gain insight on the actual practices.

Results suggest that both Malaysia and Indonesia stressed management responsibility and people management for achieving successful QE implementation. Strategic quality planning, customer involvement, and technology- and production-related resources are among the most important sub factors for both countries.

Conclusions and further research directions

This paper has presented the results of a study on CSFs for QE implementation in Malaysia and Indonesia automotive-related companies. Nine factors and 31 sub factors have been derived from this study. Ranking of the nine CSFs and 31 sub factors has provided a better understanding of the automotive industry in Malaysia and Indonesia on the direction and targets for improving practices QE. Ranking is very important because it is impossible for both countries to improve all the factors in the same time and it is hoped that with these rankings, they can focus first on improving the most critical factors found lacking and then gradually improve on the other factors.

Future research could employ the normalized weight derived from DHP methodology to develop self-assessment tool for both countries. The weights can be used to identify the score and calculate the total score point for automotive-related companies in both countries. The developed self-assessment method can be used as a tool to evaluate how well a company implements QE compared to other companies. It can also be used as a management model to determine the strengths of the company in term of QE implementation. Finally, it is hoped that the results of this study will be useful to continuously improve the application of QE within the automotive industry.

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Corresponding author
Dr Nilda Tri Putri can be contacted at: nilda_tp@yahoo.com

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The Delphi hierarchy process-based study of quality engineering in Malaysia and Indonesia automotive companies

Author(s): Nilda Tri Putri (Department of Industrial Engineering, Andalas University, Padang, Indonesia)
Sha'ri Mohd. Yusof (Department of Manufacturing & Industrial Engineering, Universiti Teknologi Malaysia (UTM), Skudai, Malaysia)
Dradjad Irianto (Department of Industrial Engineering, Bandung Institute of Technology, Bandung, Indonesia)

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Abstract:

Purpose

– The purpose of this paper is to empirically evaluate the critical factors for successful quality engineering (QE) implementation in automotive-related companies in Malaysia and Indonesia. The existence of these critical factors for the successful application of QE would help the automotive industries, especially in Malaysia and Indonesia, to be able to investigate their current QE practices and how they could be improved.

Design/methodology/approach

– Delphic hierarchy process (DHP) methodology is used in this study. The DHP method is a combination of the Delphi method and the analytic hierarchy process (AHP) approach for determining the ranking of the factors and sub factors needed for successful QE implementation. The Delphi method is employed to gather data from automotive experts in both countries and the AHP approach is used to rank the critical factors for success of QE practices.

Findings

– The findings of this study showed that the automotive industries in Malaysia and Indonesia stressed the importance of management responsibility and people management for the successful implementation of QE. Strategic quality planning, continuous improvement, and technology- and production-related resources are the most important sub factors for successful QE in both countries.

Research limitations/implications

– The series of rounds that took place during the Delphi method increased the length of time required for data collection and the follow-up process. On the basis of the consideration given, the limited resources included time, financial resources, and technical availability for this study, which resulted in the small sample sizes used.

Practical implications

– The ranking of the critical factors and sub factors for QE implementation could be useful for automotive-related companies in Malaysia and Indonesia to create action plans for improving their QE implementation.

Originality/value

– The instrument that was developed is a contribution toward characterizing critical factors for QE. Using DHP methodology, nine factors and 31 sub factors have been validated through a series of rounds of the Delphi method. It was developed based on industry experts' inputs. Therefore, the critical factors represent actual situation for QE success.

Keywords: Total quality management, Automobile industry, Quality management, Self-assessment, Quality techniques, Quality engineering, Critical factors, Delphi hierarchy process, Automotive industry

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Universitas Andalas, Department of Industrial Engineering, Padang, Indonesia

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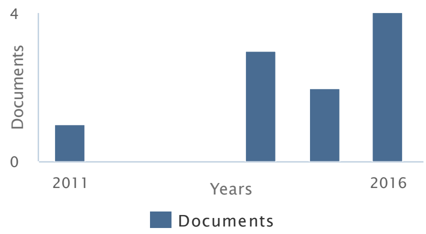

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