The Role Of Transformational Knowledge Engineering In A Malaysian Organization

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ABSTRACT:

The increase in technological diversifications creates a need for organizations to develop new practices by reviewing and integrating the key aspects of the older ones. In the same way, this study aims to examine the role of a new and improved hybrid practice known as transformational knowledge engineering in a Malaysian semiconductor manufacturing organization. A total of 226 survey responses were collected back and analysed using correlation and multiple linear regression analyses. The results showed that the relationship between transformational knowledge engineering and engineering performance was stronger than that of other individually-tested relationships. Top management should consider exploring more opportunities in this new concept and develop tactical strategies based on transformational knowledge engineering. The results can be potentially used as key implications for the engineering management practice and research in organizations. Further research in this area is required to validate the use of this model as a new sustainable competitive advantage for organizations.

Keywords: *Knowledge sharing, Knowledge engineering, Engineering performance.*

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1. Introduction

To realize the benefit of improving quality, increasing information availability, speeding up rapid technology development and responding to shorter product cycles, organizations must constantly innovate and conduct research on new ways to improve engineering performance (Abrunhosa and Sa, 2008; Tan and Vonderembse, 2006; Zhengfeng et al., 2007). Researchers and practitioners have uncovered the benefits of various industrial practices such as quality management, concurrent engineering and knowledge sharing practices in a variety of organizations. However, finding a best way to facilitate the ever-increasing demand for superior engineering performance can prove to be a challenging task (Qureshi et al., 2009).

Despite being one of the major practices in Malaysian organizations, total quality management implementations are faced with difficulties in the employees' unfavourable attitude towards quality initiatives and poor resource allocation to maintain these initiatives (Idris et al., 1996). Furthermore, although Malaysian organizations are striving to develop knowledge-based communities and systems, few organizations were successful in their efforts since there has been a missing link between knowledge management and performance outcomes (Cong and Pandya, 2003).

Although concurrent engineering helps to elevate the application of engineering techniques to a macro level, there is still a lack of understanding in concurrent engineering concepts among industrial practitioners (Cheah and Ting, 2005). The aforementioned issues in our current industrial practices clearly show that there is a need to identify and develop a new and holistic hybrid practice that encompasses all the underlying areas of importance in an organization.

Therefore, this study aims to determine the effects of transformational knowledge engineering on engineering performance, with an emphasis on a Malaysian semiconductor manufacturing organization. This study employs the use of surveys for data collection. Correlation and multiple linear regression analyses are used for this study to determine the relationships from the developed research framework.

This study provides theoretical and empirical relevance that explains the mechanisms in effective implementation of transformational knowledge engineering in a semiconductor manufacturing organization. The results can be potentially used as key implications for the practice and research concerning transformational knowledge engineering and engineering management in organizations and related initiatives.

2. Transformational Knowledge Engineering

In the scope of this study, transformational knowledge engineering refers to the combination of total quality management, knowledge management and concurrent engineering aspects. Total quality management encompasses several key determinants by itself which includes leadership, teamwork, continuous improvement, product/process management, customer focus and employee relations (Fuentes-Fuentes et al., 2004; Jung and Wang, 2006; Prajogo and Sohal, 2006).

The key determinants of concurrent engineering include process and design, cross-functional teamwork, computer-aided use for engineering design and computer aided use for cross-functional information sharing (Tan and Vonderembse, 2006; Valle and Vazquez-Bustelo, 2009). In addition, knowledge management can be divided into four components which include socialization, externalization, combination and internalization (Lee and Choi, 2003; Nonaka and Takeuchi, 1995).

The aforementioned can be combined to produce a new, holistic and practicable concept in engineering management which is known as transformational knowledge engineering. In this study, engineering performance will be considered on the whole as a dependent variable. Total quality management, concurrent engineering and knowledge management will act as the independent variables that will be linked and empirically tested against engineering performance.

2.1. Total Quality Management

Total quality management is defined as a structure of applications with a structured outcome on a organization's practices and effectiveness (Martınez-Costa et al., 2008).

According to Kaynak (2003), total quality management is a comprehensive organizational philosophy aiming to continuously improve quality using quality concepts at every level of the organization.

Total quality management is also a complex management theory formed to continually enhance product, process and service performances by meeting and exceeding customer expectations (Bayazit and Karpak, 2007). According to Forza and Filippini (1998) the concept of total quality management is characterized by the direction towards value that prevents crises and continuously improves existing conditions. Total quality management implementations require a variety of managerial skill sets to market a organization's competitive advantage and attain the best business deals out of the progressive economy (Chen and Chen, 2009).

Research in total quality management from a goal-theoretic perspective can also help resolve conflicting viewpoints which consider arbitrary numerical goals as counterproductive (Linderman et al., 2006). In manufacturing organizations that practice total quality management, a comprehensive analysis of the quality capacity of production processes should encompass the influence of the machine, person (qualification, reliability), material (condition at the time of supply, characteristics of the material), work organization (material supply, parts handling, inspection lot size) and workplace design (ergonomics, influence of the working environment) (Klatte et al., 1997).

However, Taylor and Wright (2003) protested that the recognition of total quality management among general management field researchers shows evidence of it failing to provide counteractive measures desired. They point out that there is a lack of studies on the key elements driving total quality management success.

Also, a organization that plans to employ total quality management as a rudimentary approach for its actions must bear in mind that there are various work-related environment components that can possibly hinder the success of its implementation (Fuentes-Fuentes et al., 2004). These authors argue that the environment-organization interface can cause divergences in performance outcomes achieved by total quality management implementation and can also be stipulated by the environment factor.

Prajogo and Hong (2008) argue that in spite of plentiful research concerning links connecting total quality management with organizational performances, there is but little thorough experiential research regarding the relationship between total quality management and R&D performances. Furthermore, even if it is acknowledged that total quality management is capable of engendering a maintainable competitive edge, there is, astoundingly, hardly any postulation to strengthen that confidence (Reed et al., 2000).

Also, investigations regarding the relationship between total quality management and innovativeness appear to be minimal (Perdomo-Ortiz et al., 2006). According to Prajogo and Hong (2008) employing total quality management at research and development contexts becomes taxing in contrast with additional organizational implementations because research and development functions are mainly dependable on innovation. As a result of the above, the first hypothesis is proposed:

> *H1: Total quality management correlates with engineering performance in a Malaysian organization.*

2.2. Concurrent Engineering

Concurrent engineering is a systematic approach to the integrated, simultaneous design of products and their related processes, including manufacture and support (Winner et al., 1988). The concurrence in concurrent engineering means that more resources will be spent in early concept and design stages of the development process, to avoid spending far more during the relatively costlier rework process to make a product function as intended (Jones, 2007). Concurrent engineering also refers to interdisciplinary collaborations and corresponding efforts to achieve universal targets in new product development, production, marketing and sales (Kusar et al., 2004). Concurrent engineering, which differs from the traditional and sequential design technique, involves methodical approaches for assimilating concurrent product designs and the associated processes concerned (Xu et al., 2007).

Concurrent engineering applications are known to have a profound effect on the future of manufacturing management because they employ simultaneous product, service and organizational development teams to improve, manufacture and market products and services in advance, at a superior merit and a lower cost (Cleland and Ireland, 2007). In reality, lead time, costs, economic conditions and quality are interconnected characteristics and the concurrent engineering approach aims to combine these characteristics and present a general outline for organizations (Abdalla, 1999).

Starbek and Grum (2002) suggest that although customer expectations which concern functionality and quality in products seem to be constantly growing, customers will normally not pay more in favour of a superior product with delayed deliveries. The basic concern in concurrent engineering is to make available all relevant information to an agent involved in the design process before the design task is begun (Yassine et al., 1999). In order to execute this efficiently, it is important for management to effectively disseminate constructive information at all levels of the design process.

Concurrent engineering acts as the instrument to decrease improbability to improve a organization’s competing advantage through encouraging debates, clarifications, enactments and enabling knowledge dissemination throughout the organization rapidly and efficiently (Koufteros et al., 2001). A organization that desires to seek out new customers through means of reducing manufacturing assembly expenses should take this opportunity to design a complete product life cycle to create new objectives and insights in new product development (Bernard et al., 2007).

Hsiao (2002) posits that the development of high quality and low cost products is undeniably an imperative policy in most manufacturing organizations seeing as it enables the implementation of concurrent customer-oriented design methods for commercial excellence. In concurrent engineering processes, there is not only an overlap among the upstream and downstream design work, but also reengineering of new product development which involves product design engineering at the very beginning phase of product development (Wang and Yan, 2005).

On the whole, concurrent engineering practices require pre-requisite changes in organizational policies and management strategies, with an emphasis on human resources and process management (Haque et al., 2000). Concurrent engineering projects engage the institution of cross-functional design groups to concomitantly reflect on a variety of actions all through the whole product life cycle (Chen and Lin, 2004).

However, recent studies demonstrate the inability of concurrent engineering to attain optimistic outcomes along with the level in equivocality that exists during innovative processes, hence limiting its impact on development attributes in performances to be affected (Valle and Vazquez-Bustelo, 2009). Wang and Yan (2005) argue that superimposition flanked by upstream and downstream actions causes deficiencies too. Consequently, there would be a likelihood of more design mistakes and redesign work. This therefore gives way to the formulation of the second hypothesis:

> *H2: Concurrent engineering correlates with engineering performance in a Malaysian organization.*

2.3. Knowledge Management

Knowledge management is a management mindset that includes building on past experiences (libraries, data banks, smart people) and creating new vehicles for exchanging knowledge (knowledge-enabled intranet sites, communities of practice, networks) (O'Dell et al., 1998). It is a new emerging, interdisciplinary business model that has knowledge as its main focus within the framework of an organization (Awad and Ghaziri, 2003). It also refers to the process of generating importance using a organization's indefinable advantages, which include uniting conceptions of information technology, computer technology, industrial re-engineering, organizational performance and other technological related areas (Liebowitz, 1999). The more efficient a organization sustains its knowledge management processes, the more efficient the integration process of these concepts and technologies (Gold et al., 2001).

The greatest knowledge management undertakings are emphasized more on enabling than on managing the flow of knowledge (Zhengfeng et al., 2007). Knowledge sharing is observed to be a groundwork on continuous improvement in manufacturing and product development processes (Lee and Chang, 2006). Nonaka and Takeuchi (1995) believe that the success of many Japanese manufacturing organizations are not because of their production ability or collaborative relations among consumers, but because of their advantageous ability in organizational knowledge creation.

Organizations with good knowledge management approaches will have flourishing and improved product development performance because the knowledge shared within communities enable technologists to further develop and improve their processes (Liu et al., 2005). These communities of practice are therefore able to develop useful formations for knowledge management and technologies.

In terms of knowledge management implementations in manufacturing organizations, Faniel and Majchrzak (2007) point out that engineers have to be quick in sourcing for detailed or summarized facts from various areas or departments for them to better understand the cross-functional knowledge and establish their roles in existing problems.

As far as knowledge management is concerned, even though the best Western approach on knowledge management standards can be frequently viewed as generally of significant importance, there is still a lack of research on organizational implementations that enhances knowledge management in conflicting cultural conditions (Hsu, 2006). Thus, the third hypothesis can be proposed as follows:

> *H3: Knowledge management correlates with engineering performance in a Malaysian organization.*

2.4. Engineering Performance

Many organizations today disregard the importance in evaluating engineering performance and merely focus on meeting the cost and time requirements of manufacturing projects (Qureshi et al., 2009). The preceding assertion points out that there is an evident and dire need for organizations to realize and embrace the necessity to continuously evaluate engineering performance and the factors that are linked to it.

The uniqueness that impinges on engineering performance is of a simple form, whereby the epigrammatic link between engineering performance and some characteristics that influences it is often demonstrated in a research (Cho et al., 2009). In manufacturing projects, once a decision has been done, the execution time should be kept as brief as it could, as time is an aspect of success that provides additional timelines for the dealings leading to the decision (Thiry, 2002). Hence, it is evident that time is a very valuable and important aspect in manufacturing projects which contributes to the development of engineering performance.

Projects that are delayed will incur additional cost and dissatisfy customers, causing the financial support difficulties and further slippages in project timelines to transpire (Kaliba et al., 2009; Kamrul & Gunawan, 2009). Therefore, the control of project costs and financial expenditure is also important in productive engineering performance.

Countless outstanding benchmarking studies during the past four decades have given attention to new product development (NPD) success across hundreds of projects and practically every one of them discovered that the crucial project success factor is ‘product superiority’ (Stevens et al., 1999, p. 455). In manufacturing, product superiority signifies distributing distinguished products that provides exceptional benefits and quality features to customers (Cooper, 1996). Thus, in most manufacturing projects, this superiority element in products has an important role and significant effect on engineering performance.

The most indispensable aspect desired among development engineering groups has to be creativity because existing knowledge is frequently found insufficient to conform with the novel conditions necessary in competing for superiority (Leenders et al., 2002). Creativity is an essential aspect of engineering performance as it involves creative idea generation and innovation that is exceptionally useful for the conceptual stages in manufacturing projects (Garcia and Calantone, 2002; Leenders et al., 2002).

Many organizations also need to effectively understand and manage risks associated with developing new products since there is a persistently high probability of new product failure and large financial loss (Schmidt et al., 2009). Thus, product development performance is also yet another essential aspect in engineering performance to be given attention to since it is a critical factor that determines the success or failure of a project.

From the aforementioned discussions, it can be summarized that engineering performance includes the monitoring and management of factors such as time, cost, superiority, creativity and product development performance. From the literature survey carried out, there appears to be no studies conducted so far on the systemic and compounded effects of transformational knowledge engineering on the engineering performance in Malaysian manufacturing organizations. Seeing as total quality management, concurrent engineering and knowledge management have several very common attributes and objectives, it would also be important to understand the overall level of effect that they would bring to an organization's engineering performance. Hence, by combining all the industrial practices discussed, a fourth hypothesis is developed:

> *H4: Transformational knowledge engineering influences engineering performance in a Malaysian organization.*

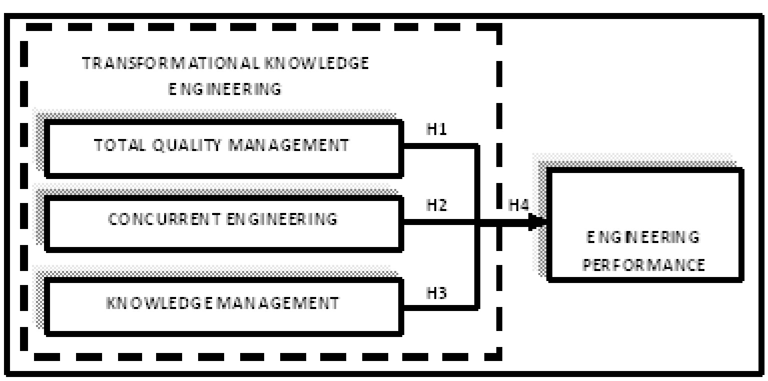

Figure 1: The Research Framework

Figure 1 presents the proposed hypothetical research framework for this study. The proposed framework suggests that superior engineering performance can be attained if the three practices were to be merged to form transformational knowledge engineering. This proposition, however, will require further empirical validation. The following sections will discuss the methods to facilitate this gap.

3. Research Method

The organization chosen for this study was founded in Malacca, Malaysia 12 years ago and has been applying total quality management, concurrent engineering and knowledge sharing practices in their semiconductor manufacturing and production activities for more than 5 years. This organization has about 43,000 employees worldwide, with 6000 of them involved in research and development. Other than in Malaysia, this organization also operates in Germany, Austria, France, Taiwan, Singapore and China.

In this study, survey forms were handed out to all the project leaders, managers and engineers in the organization. Based on figures provided by this organization on projects in the last 2 years (since 2009), the organization had 3000 projects in total. Due to high turnover rate, transfers and resignation of project leaders, some projects are discontinued. Thus, a total of 2100 surveys forms were handed out to the respondents of the organization according to workable projects.

As such, the unit of analysis for this study was the personnel's respective projects in the organization. Duration of 6 weeks was used to gather the data. The response attained was 226 usable surveys forms out of the 2100 surveys that were handed out, which produced a response rate of 11%. The data was gathered and analyzed using the SPSS 18 software, a quantitative analysis application used for statistical analysis. The statistical methods employed were correlation and multiple linear regression analyses.

4. Results

Pearson's correlation analysis is used to evaluate H1, H2 and H3. The following tables present the results on the relationships among total quality management, concurrent engineering, knowledge management and engineering performance. Table 1 presents the correlation analysis used to evaluate 'H1: Total quality management correlates with engineering performance in a Malaysian organization'. The correlation between total quality management and engineering performance is 0.677 with a p value of 0.000. Thus, the relationship between total quality management and engineering performance is positive and significant. Hence, H1 is not rejected.

Table 1: Total Quality Management – Engineering Performance Correlation

Test	Output	Interpretation
Pearson's Correlation	0.677***	Positive Correlation
Sig. (2-tailed)	0.000	Significant

*significant at $p < 0.05$ level, **significant at $p< 0.01$ level, ***significant at $p < 0.001$ level

Table 2 presents the correlation analysis used to evaluate ***'H2: Concurrent engineering correlates with engineering performance in a Malaysian organization'***. The correlation between concurrent engineering and engineering performance is 0.698 with a *p* value of 0.000. Therefore, the relationship between concurrent engineering and engineering performance is positive and significant. Hence, ***H2*** is not rejected.

Table 2: Concurrent Engineering – Engineering Performance Correlation

Test	Output	Interpretation
Pearson's Correlation	0.698***	Positive Correlation
Sig. (2-tailed)	0.000	Significant

*significant at $p < 0.05$ level, **significant at $p < 0.01$ level, ***significant at $p < 0.001$ level

Table 3 presents the correlation analysis used to evaluate ***'H3: Knowledge management correlates with engineering performance in a Malaysian organization'***. The correlation between knowledge management and engineering performance is 0.685 with a *p* value of 0.000. Therefore, the relationship between knowledge management and engineering performance is positive and significant. Hence, ***H3*** is not rejected.

Table 3: Knowledge Management – Engineering Performance Correlation

Test	Output	Interpretation
Pearson's Correlation	0.685***	Positive Correlation
Sig. (2-tailed)	0.000	Significant

*significant at $p < 0.05$ level, **significant at $p < 0.01$ level, ***significant at $p < 0.001$ level

A stepwise multiple linear regression was conducted to evaluate **'*H4: Transformational knowledge engineering influences engineering performance in a Malaysian organization*'**. The total amount of independent variables tested was three (Total quality management, concurrent engineering and knowledge management) for ***H4***. Using the formula provided by Tabachnick and Fidell (2001), the minimum sample size required would be 50 + (8 × 3) or 74 respondents. As such, the sample size criterion was met for this study.

Regression formulae are based on the assumption that residuals are normally distributed around the predicted dependent variable scores. For this study, normal probability plots were generated to test this. In the normal probability plots, since the points were in a reasonably straight diagonal line from bottom left to top right, it can be confirmed that there were no major deviations from normality (Pallant, 2005; Tabachnick and Fidell, 1996). For the normality test, the measure of kurtosis and skewness values for the variables tested were within the prescribed |1.0| range (Tabachnick and Fidell, 1996). Having satisfied the assumptions for regression analysis, all of the independent variables were regressed against engineering performance and the results are summarized in Table 4.

Table 4: Multiple Linear Regression For Transformational Knowledge Engineering – Engineering Performance

Transformational Knowledge	β	Std. Error	t	F	R	R^2

Engineering						
(Constant)	1.443	0.172	8.409***			
TQM	0.154	0.075	2.060*			
CE	0.218	0.081	2.683**	86.680***	0.734	0.539
KM	0.283	0.069	4.134***			

(Notes: * p<0.05; ** p<0.01; *** p<0.001; *N*=226; Durbin Watson = 1.645)

The results in Table 4 indicate that up to 53.9% of the variance in engineering performance is explained by transformational knowledge engineering. A correlation coefficient (R=0.734) was also obtained for this relationship. In addition to that, the model is significant as indicated by the ANOVA results of F (3, 223) = 86.680, p<0.001. Thus, the fourth and final hypothesis, ***H4***, is supported.

5. Discussion

From the results of hypothesis *H1*, *H2*, *H3* and *H4*, it is evident that transformational knowledge engineering plays a significant role in developing engineering performance in this organization.

In hypothesis *H1*, total quality management is significantly and positively related to engineering performance. This finding empirically validates the fact that total quality management enhances an organization's effectiveness through continuous improvement of quality in products, processes and customer satisfaction (Bayazit and Karpak, 2007; Martınez-Costa et al., 2008). In this context, the organization highly depends on the development and manufacturing of its technology and processes to attain quality products for competitive business and therefore, rely a lot on the performances of their engineers.

In hypothesis *H3*, knowledge management also proves to be positively and significantly related to engineering performance. This finding corresponds to the findings of Liu et al. (2005) who theorize that organizations with good knowledge sharing practices will have flourishing product development performance. This is not only true for the current findings from this organization but is also further emphasized on the fact that an engineer is apt in using facts sourced from supplementary areas once these facts are obtainable by synopsis as well as thorough levels so as for them to better understand the knowledge and establish roles the knowledge may contain in current problems (Faniel and Majchrzak, 2007).

Besides that, this finding also enhances the mechanisms from *H3*'s analyses. Majority of the survey respondents were involved in engineering projects. In this manufacturing organization, it is normal for members of engineering projects to collaborate across departments. Cross-functional teams are instruments for learning prospects that generate knowledge sharing which is observed to be a groundwork on continuous quality improvement in development processes and in products (Koufteros et al., 2001; Lee and Chang, 2006).

In hypothesis *H2*, it is observed that concurrent engineering is also positively and significantly related to engineering performance, with the highest correlation of

R=0.698. Although the correlation analyses for *H1*, *H2* and *H3* produced correlation values that are almost equivalent, it is clear that the principal and underlying variable for productive engineering performance in this organization is concurrent engineering. This finding is therefore consistent the findings of Koufteros et al. (2001), who believe that concurrent engineering is an instrument to decrease improbability and improve competitive advantages in organizations.

The fourth hypothesis sought to investigate the influence of transformational knowledge engineering on engineering performance. The results indicate that up to 53.9% of the variance in engineering performance is explained by transformational knowledge shaing. This shows that the proportion of total variance contributed by total quality management, concurrent engineering and knowledge management is strong due to the high correlation obtained (*R*=0.734) which is within the range of 0.7 to 0.9 (Brown, 2009; Francois, 2010; Johnston, 2007).

Besides that, it is found that the overall correlation coefficient improves when the independent variables are compositely tested against engineering performance. This is because, according to Galbraith (1973), there is no best, near-to-best or uniformly standard effective way to ideally manage an organization. From the regression model developed, it is therefore proven that engineering performance can be improved when not just one, but all the key determinants (total quality management, concurrent engineering and knowledge management) interact as a whole in developing engineering performance.

The validation of the last hypothesis supports the proposition that achieving success in engineering performance concerns more than just the accomplishments in time, cost and quality goals, but also the appropriate mechanisms to be understood to attain more tangible outcomes such as product completion and objective fulfilments (Pheng and Chuan, 2006). These mechanisms can be understood through the application of transformational knowledge engineering, which ensures focus in quality, concurrency and knowledge management.

This section presents the discussion on the obtained results, presenting both the theoretical and practical aspects on knowledge sharing behaviours among teams based on the role of quality and cross-functional teamwork in engineering performance in the studied firm.

6. Conclusion

The findings have shown that the practices of transformational knowledge engineering implemented in engineering projects can enhance the engineering performance. The independent variables have positive and significant relationships with engineering performance. Among all of them, concurrent engineering practices proved to be the strongest in their importance for improved engineering performance followed by knowledge management and total quality management.

Top management should create more opportunities and initiatives to explore the benefits of concurrent engineering in order to achieve greater competitive advantage and reducing product lead time to market. One of the proposals is to provide proficient training and teambuilding activities to enhance cross-functional teamwork which is important for concurrent engineering and knowledge management practices.

The main limitation is the sampling method employed which limits the generalisability of this study beyond the context of this organization. Due to time as well as budgetary constraints, this study took on a case study approach in which it was only conducted within a large Malaysian organization. As such, the findings of this study needs to be interpreted within this context and cannot be generalized to other organizations in Malaysia.

Apart from that, a simultaneous modelling analysis in this study is also not possible because the model is developed as such that the variables are not able to be concurrently tested against each other. This limits the possibility of discovering more relationships and effects among the dependent and independent variables.

A few suggestions are proposed to further improve the study and findings. The first suggestion is related to the survey method of conducting the study within a single organization. It is proposed that this study can be further extended to other manufacturing organizations in Malaysia to evaluate the practice of transformational knowledge engineering. This would allow for greater generalisability of the findings.

Another suggestion is to conduct in-depth qualitative studies in every technology cluster or business unit of this studied organization to further understand its organizational context to explain in more depth the role of transformational knowledge engineering in organizations. Also, observational techniques could be employed to shed more light on this phenomenon. In addition, instead of using respondent-reported transformational knowledge engineering and engineering performance scales, it would be better if researchers are able to use empirical data from the organization's records e.g. sales performance, customer satisfaction, development cost etc.

Also, a structural equation modelling (SEM) approach using a combination of statistical data and qualitative causal assumptions can be used in order to test and estimate causal relationships. One of the available software that can be utilized for this analysis is called AMOS. Using this approach, the variables for this study are capable of being tested simultaneously altogether instead of the conventional method where they are linearly tested with only one variable against another.

Despite the main sampling limitation, this study stresses on the applied mechanism of transformational knowledge engineering in a semiconductor manufacturing organization with an emphasis on engineering performance. This study would still be useful for other semiconductor organizations since the findings can be generally used as guidelines in their efforts to recognize transformational knowledge engineering as a new and enhanced practice in the marketplace.

Overall, top management should explore the opportunities in this new concept of implementing transformational knowledge engineering as part of their strategy for competitiveness. There is ostensibly ample room for research and improvement in the current model developed for this study. Further research in this area is required in order to validate the use of transformational knowledge engineering as a new sustainable competitive advantage for organizations.

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