Engineering Performance: The Role Of Knowledge Sharing Teams In A Malaysian Manufacturing Firm

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ABSTRACT

In most manufacturing industries, knowledge sharing teams accentuate the importance in cultivating knowledge sharing initiatives which would eventually lead to improved project performance. To understand this contribution factor, this study is conducted to examine the effects of knowledge sharing teams (which comprise of quality teamwork and cross-functional teamwork) on engineering performance in a Malaysian manufacturing firm. In this study, semi-structured interviews and surveys are conducted to gather qualitative and quantitative evidence. Our findings suggest that there is a significant and positive relationship between knowledge sharing teams and engineering performance. The findings also suggest that 44.8% of the variance in engineering performance is explained by quality and cross-functional teamwork. However, it is observed that there are barriers in interdepartmental collaborations when it comes to cross-functional teamwork. From our findings, we conclude that this is possibly due to the nature of the industry which consists of long and complex process flows. Thus, a possible solution would be to form a specific project group which could eliminate barriers in knowledge sharing among team members and cultivate cross-functional teamwork.

Keywords: *Knowledge sharing, Engineering performance, Quality, Cross-functional teamwork*

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1. Introduction

To avoid the wastage of valuable resources, there is need to intensify engineering performance, more than ever in circumstances of management performance whereby finding techniques to evaluate it is not easy (Qureshi et al., 2009). Additionally, understanding the specific linkages between team environment, leadership and engineering performance seems to be considerably more difficult, especially in complex work environments (Thamhain, 2004). Therefore, it can be generally understood that engineering performance is still considered a vague measure that requires more study in various contextual aspects and environments.

Jin and Ling (2006) point out the gap in research on seeking out aspects influencing engineering performance through perspectives of relationship-building. According to Bonner et al. (2002), although traditional formal diagnostic controls play a role in management's attempt to keep new product development (NPD) teams on an appropriate strategic track, too much of it might limit the creativity of the group, obstruct the team's movement and inhibit the team's true potential and capacity in the achievement of success. From the aforementioned studies, it can be seen that teamwork is apparently an important factor that can enhance engineering performance, but is improperly, or in most cases, not measured, thereby causing hindrances and obstructions in improving engineering performance. Furthermore, it is also of interest to study the possible obstructions of knowledge management initiatives in improving engineering performance to develop Malaysian manufacturing firms and help them sustain with Malaysia's growth, both economically and technologically (Tehraninasr and Raman, 2009).

Simkhovych (2009) stresses that many projects fail because of the paucity within multicultural teams to correspond and cooperate with each other. According to Thamhain (2004), teamwork bring out the importance of traditional project performances such as NPD performance and also in employing organizational and technology change. However, no studies have been carried out concerning the influence of knowledge sharing teams on engineering performance in the context of Malaysian manufacturing firms. Hence, this study is conducted in order to investigate the effectiveness of knowledge sharing teams on the success of engineering performance in a Malaysian manufacturing firm.

In this empirical study, the variables of knowledge sharing teams include quality teamwork and cross-functional teamwork. From these variables, hypotheses will be formed and analyzed using correlations analysis, reliability analysis and multiple linear regression analysis. Practical and theoretical implications as well as proposals shall be developed from the statistical results, which will then lead to the overall conclusion.

2. Knowledge Sharing Teams

Knowledge sharing teams consist of communities that share knowledge and are the enablers of process improvement initiatives for manufacturing organizations (Liu et al., 2005). Love and Roper (2009) suggest that knowledge sharing teams play a significant role in innovative process development which allows knowledge sharing to take place and overcome organizational barriers. In this study, knowledge sharing teams is observed as a combination of quality teamwork and cross-functional teamwork. The subsequent sections will present the literature on both forms of teamwork.

2.1 Quality Teamwork

Quality teamwork is portrayed in a structure of quality circles and quality improvement teams and is capable of inspiring staff and develop staff performance and self-efficacy if carried out successfully (Jun et al., 2006). Fuentes-Fuentes et al. (2004) affirm that within surroundings of elevated degrees in volatility, diverse within customer-satisfying actions and resources favourable in terms of growth, quality teamwork among the firm members in cross-functional scopes will be bigger.

Quality teamwork can be viewed as the achieved result for a firm which focused on knowledge sharing activities as well as adapting in modifications formed through total quality management (TQM) enhancement, whereby prospective learning opportunities are better in team settings than in individual ones (Fuentes-Fuentes et al., 2006). Carr et al. (2008) suggest that general goals in multifunctional synchronization encourage dialogues along with the sharing of concepts among operational sections, ranging at consumer needs headed for technical drafting and possible novelty in resources provided by main contractors, to assist firms in improving product quality. These suggestions point out that quality teamwork is a good avenue for learning opportunities and knowledge sharing.

A quality team can help discover and share best-practices throughout an organization by facilitating quality management and yield perfection, improving labour-management communication and improving work satisfaction and the quality of work life for engineers (Cleland and Ireland, 2007). Therefore, according to this study, quality teamwork can also determine a satisfactory working life style.

From a human resource management perspective, the training of human resources on quality teamwork and staff selections according to classifications of job proficiency contribute to greater industrial innovation capability (Perdomo-Ortiz et al., 2006). Linderman et al. (2006) suggest that the formation of knowledge occurs through deliberate learning that utilizes official improvement methods and intended learning, which involves ruling of measures taken by organizational team members. Hence, it is obvious that quality teamwork also comes hand in hand with proper and structured training methods in order for it to be a success.

Nevertheless, Hoegl et al. (2003) argue that a deficiency in cooperation within a team leads to replicated efforts and absent liability for certain errands and activities in the task process and thus hinders the team's capacity to finish its project within appropriate time and cost constraints. Scott-Young and Samson (2008) also criticize that although well-organized executions in projects are major industrial objectives for manufacturing firms, current study provides diminutive ways on teamwork factor influences toward cost, schedule and operability.

In short, research gaps identified for this study are to what extent lack of collaboration and responsibility impedes engineering performance and how quality teamwork in the firm can influence cost, schedule and operability. Hence, the following sub-hypothesis is proposed:

> *H1: Quality teamwork correlates with engineering performance in a Malaysian manufacturing firm.*

2.2 Cross-functional Teamwork

A major initiative in putting effective teamwork into practice is effectual cross-functional teamwork, that incorporates development via organizational and information management processes in an encouraging supervisory and directorial atmosphere (Abdalla, 1999). Ma et al. (2008) reiterate that cross-functional engineering teamwork is a hi-tech process that sustains dispersed, multidisciplinary and multi-organizational groups throughout the NPD and production phases. From the preceding definitions, it is palpable that cross- functional teamwork is complex and multidisciplinary in nature and also requires proper governance and control from management leadership.

Badr Haque et al. (2000) define cross-functional teams as engineers from divergent and specific expertise operating on multifarious design duties with deviating principles, flare and potentials. Chen and Lin (2004) summarize that complex projects in engineering environments call for extremely specific participants in teams that possess fine understandings on prerequisites of supplementary designing jobs, or in other words, cross-functional groups that gather collectively information in assorted functioning sections for developing feasible results of designs. In short, cross-functional teamwork which is highly multidisciplinary provides a good platform for knowledge sharing amongst different engineering functions in order to ensure efficiency in carrying out engineering projects.

Multiplicity amid groups which add to the NPD process is fitting since agents from these groups have singular and separate undertakings and obligations (Susman and Ray, 1999). Cordero et al. (1998) found that technical professionals working on cross-functional teams have a higher value in job satisfaction than those not operating in a team. They then concluded upon operating in multifunctional projects, a team can raise values in job satisfaction for them. Therefore, the aforementioned suggestions prove that cross-functional teamwork also enhances the richness in work distributions which enables engineers to function to their fullest content and have a variety of experiences and learning opportunities.

Cross-functional teams offer opportunities for components to convey queries and is an instrument for learning prospects (Koufteros et al., 2001). The desired communication patterns in the concurrent strategy are accomplished through a cross-functional team formed during the beginning phases of the upstream task with representatives from the front-end and back-end tasks so as to enhance the knowledge accumulation rate for the front-end task by including and discussing back-end concerns early in the development process (Yassine et al., 1999). From the suggestions, it is clear that cross-functional teamwork improves the richness of quality information and knowledge which is shared among different functions. This occurrence can speed up the development and manufacturing life cycle and thus enhance the engineer's performance.

The foundation for carrying out parallel engineering falls in teamwork among functions and amid specialists supervising every process (Portioli-Staudacher et al., 2003). Cross-functional teams are often set up for overlapping purposes that require different actors to involve communication and collaboration more vigorously than in the past situations (Haque et al., 2000). Valle and Vazquez-Bustelo (2009) discovered that there are advantages when engineering as well as communicative abilities among groups improved along with better motivation in experimenting industrial collaboration occurring through combining knowledge concerning multidisciplinary skills. Therefore, cross-functional teamwork also enhances communication among different functions which enables engineering team members to be more motivated in carrying out their studies and evaluations that consists of different or new knowledge from other functions.

Cross-functional teamwork is an imperative attribute of engineering that involves the beginning of the combination and reengineering of the NPD process (Wang et al., 2003). Valle and Vazquez-Bustelo (2009) suggest that cultivating cross-functional teamwork in an engineering team requires new product development members' involvement at early stages in projects, open interactions in addition to trading knowledge, although still, close relations are a must to strengthen each other to attain team objectives. Hence, a collaborative effort involving upstream and downstream processes in manufacturing industries is important for cross-functional teamwork to make a difference in engineering performance.

Teamwork competence of cross-functional teams and working affiliations amongst members unswervingly influence cross-functional team performance and are a vital ingredient for an effective team that must not be disregarded (Chen and Lin, 2004). The common resourceful method to reduce lead time for projects is to decrease the modification regularity by evidently laying out tasks and advantages, edifying confidence amid functional teams (O'Sullivan, 2003). Therefore, as far as collaboration among different functions is concerned, engineering team members will still be required to be fully cooperative in order to reach a consensus and avoid duplicated efforts that can waste time in the projects.

Cross-functional teams are linked with superior cost performance and more rapid manufacturing and development timelines (Scott-Young and Samson, 2008). However, Susman and Ray (1999) argue that the larger the divergence amongst functions, the larger the obstructions of incorporating these functions on the road to success of a general goal. Therefore, more time can be possibly wasted due to the complexity of the project team and this can lead to extended development timelines which would lead higher cost performance.

Cordero et al. (1998) suggest that technical professionals who work on project teams interact more with other functions and experience more teamwork compared to technical professionals who work on research and development groups. Haque et al. (2003) posit that the key barrier to the triumph of cross-functional teamwork often was the poor partaking and dedication of team members, predominantly the major product development group. The theory in the aforementioned suggestions shows that more often than not, development groups are more prone to hinder the interactions amongst functions, causing poor cross-functional teamwork in projects.

In brief, studies are still needed in areas regarding the influences on cross-functional teams in cost and time performance and the challenges faced in implementing this in engineering projects of various functional differentiations. From the preceding findings, we can summarize that there may still be a gap in the research area concerning cross-functional teamwork in product development teams and on how cross-functional teamwork can impact engineering performance. Therefore, the following sub-hypothesis is proposed:

H2: Cross-functional teamwork correlates with engineering performance in a Malaysian manufacturing firm.

Based on the literature review, knowledge sharing teams are segregated into two variables (Quality and cross-functional teamwork). The relationship between each variable to successful engineering performance was hypothesized. Hence, by combining all elements of teamwork and testing its' overall influence towards engineering performance, a third hypothesis is developed:

H3: Knowledge sharing teams influence engineering performance in a Malaysian manufacturing firm.

Thus, a research framework such as the one in Figure 1 is proposed for this study.

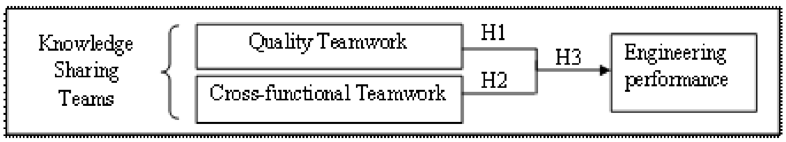

Figure 1: Research Framework

3. Research Method

The organisation chosen for this study is a large Malaysian semiconductor manufacturing firm which has used various knowledge sharing and teamwork approaches in managing engineering projects. For the interview study, the population of the study consists of all the project leaders in this firm. As such, the unit of analysis for this study is the project leaders in the organization. This study not only employed the use of surveys but also semi-structured interviews to obtain the insights of team leaders in the semiconductor manufacturing firm on the role of quality and cross-functional teamwork on engineering performance.

Guided by an interview protocol, a total of eight experienced project leaders were interviewed for approximately 45 – 90 minutes on how quality and cross-functional teamwork influences the manufacturing firm's engineering performance. These respondents were selected for the interview based on their project leadership experience and tenure in the firm. The interview session was recorded using a voice recorder and later transcribed for analysis using NVIVO 8, qualitative analysis software application to identify the emerging codes and themes.
To ensure the anonymity of the interview participants and to facilitate data analysis, each interview participant is assigned an identifier. Details of the interview participants are outlined in Table 1. The structure of the interviewee quotes and comments were divided amongst the independent sub-variables which are quality teamwork and cross-functional teamwork.

Table 1: Details Of Interview Participants

Identifier	Position title	Sex	Years of work experience	Years of experience as project leader
Alvin	Production Manager	Male	12	2
Anna	Senior Manufacturing Engineer	Female	8	2
Charles	Manufacturing Manager	Male	13	8
Harry	Project Manager	Male	20	11
Kathy	TQM Executive	Female	20	12
Kelly	Process Engineer	Female	4	1
Raymond	Engineering Sample Engineer	Male	3	3
Teresa	Quality Engineer	Female	5	3

For the survey study, surveys were handed out to all project leader personnel in the firm. The population of the study consists of all the project leaders, managers and development personnel in the firm. Based on figures provided be this firm on projects in the last 2 years (since 2009), the firm had 3000 projects in total. Due to high turnover rate, transfers and resignation of project leaders, some projects are discontinued.

As such, the unit of analysis for this study is the leader's respective projects in the organization. Thus a total of 2100 surveys were handed out to the respondents of the firm according to workable projects. Duration of 6 weeks was used to gather the data. The response attained was 226 usable surveys collected back out of the 2100 surveys handed out, which produced a response rate of 11 percent.

In this study, the attitudinal scales used are seven-point Likert-type scales. Respondents are asked to choose one out of many response alternatives which are based on the 7-point Likert-type scale. This scale is chosen because psychological research has proven that people will have complexities reliably making more than seven distinctions (Weisberg et al., 1996). The questionnaire is composed of closed-ended questions adopted from the key sources identified in the literature (see Table 2).

Table 2: Variable Development And Reliability Analyses For Teamwork Variables

Variable	**Sub-variable**	**No of items**	**Source**	**Cronbach's alpha, α**	**Overall cronbach's alpha**
Knowledge sharing Teams	Quality Teamwork	8	(Fuentes-Fuentes et al., 2004, p. 438)	0.848	0.886
	Cross-functional Teamwork	3	(Valle and Vazquez-Bustelo, 2009)	0.844	

Cronbach's alpha is used in this study to evaluate the internal consistency of the survey items. Typically, the alpha value can range from 0 to 1. The rule of thumb to measure the value is based on an alpha coefficient must be above 0.7 to signify high reliability (Cronbach and Shavelson, 2004; Nunnally and Bernstein, 1994). The reliability test shows that the Cronbach's alphas for all sub-variables are acceptably above 0.7.

Pearson's correlation is used in the analysis of data to see the significance, nature, direction and bivariate relationship of the variables used in this study (Sekaran, 2003). More specifically, this test was used to evaluate Hypotheses 1 and 2. Apart from that, multiple linear regression is chosen to examine Hypothesis 3 to ascertain the relationship of the both quality and cross-functional teamwork (independent variables) with engineering performance (the dependent variable) (Bryman and Bell, 2003, pp. 245-246).

4. Results

This section presents both qualitative and quantitative evidence on the effectiveness of knowledge sharing teams on engineering performance in a Malaysian manufacturing firm. The qualitative findings are gathered to provide preliminary evidence to support the hypothesis proposals for the survey-based study. A quantitative analysis such as a survey study was needed because it gives a numerical description of the sample's voting intentions (Arksey and Knight, 1999), which provides an even more definitive conclusion for this study.

4.1 Interview Findings On Quality Teamwork

In terms of quality teamwork, Alvin and Harry state that *'everyone has their own targets to achieve'*. Managers and suppliers in diverse sections normally operate autonomously towards achieving the section's individual targets whereby they have their own individual prioritized targets to work upon (Harry). Despite this, quality teamwork is still strong among employees within those departments (Alvin). Kathy agrees that *'quality teamwork is a good thing for the firm's development'*. Thus, this finding shows that quality teamwork is practiced in the firm, but stronger within the individual departmental projects.
Employees in the firm are also not afraid to voice their opinions and ideas since the culture there encourages them to do so through "Your Idea Pays" program where engineers make suggestions and implement them on the production floor and any queries are answered during the mass communication platform (Kelly and Teresa). Anna believes that *'the mass communication held in the firm is very important as it gives all engineers a chance to voice out their queries to the top management'*. The findings propose that the firm provides a platform for quality engineering teams to voice out or share their point of view and does not limit their ideas.

Overall, in quality teamwork, Alvin and Charles relate that *'the firm has been standing strong for 35 years without any barriers and teamwork everywhere'*. This is important in their work culture as it reflects personal commitment towards customer satisfaction, breakthrough ideas through innovation, working together with one another as partners and creating values for customers and society (Charles). However, out of the 8 interviewees, Kelly, Raymond and Teresa believe that *'barriers still exist among departments and there is still lack of unity in the firm'*. Raymond points out that *'although these barriers exist, they still can be resolved if parties come to consensus in a win-win opportunity kind of situation'*.

In short, it can be seen that the firm cultivates an environment of quality teamwork in order to achieve individual departmental targets. A successful project in this firm often relies on strong cooperation and collaboration amongst employees. Furthermore, the opportunity to voice out opinions on projects allows effective management without much problems or uncertainties. Although barriers in cross-functional teamwork do exist, the firm is still doing its best to compromise the situation to benefit all team members from different groups.

4.2 Interview Findings On Cross-Functional Teamwork

As far as cross-functional teamwork is concerned, the company's product development group demonstrates strong cross-functional teamwork (Alvin). Their disciplines cover each process and are inter-related, enabling the engineers to perform more efficiently in cross-functional programs (Charles). In developing a product or process, teamwork among these engineers is extremely important and weekly reviews and meetings are often conducted to ensure a smooth flow of their projects (Harry). However, Kelly and Teresa think that *'although the development team consists of interdisciplinary fields in engineering, often the scope of their engineering fields is not very related to their cluster, sections or projects'*. Thus, from the findings, it can be seen that the level of cross-functional job scopes is strong among the development groups but is often generically distributed among the engineers, causing incompatibilities in terms of skill sets.

Some projects involve manufacturing and process at an early stage of development, such as EES (Early Engineering Samples) projects (Raymond). However, not all projects involve manufacturing and process in the early stages of product development (Kathy and Charles). Anna points out that *'in her experience as a manufacturing engineer, she has never seen the involvement of process, manufacturing or product engineers at an early stage for some products'*. Charles explains that *'this is due to the nature of the processes, whereby it may be more suitable to apply current processes or manufacturing methods to some new products'*. By doing this, upstream processes would not need to know what their downstream are involved in and just apply their current existing process upon the new products (Charles).

In summary, it is apparent that the firm's product development team consists of cross-functional engineering teams that work together in order to achieve better performance in their projects. Due to the cross-functional nature of these teams, the employees from different departments were required to have regular progress review meetings so that all functions involved can gather together and contribute their ideas or concerns on the project. However, not every scope the development team's engineering fields may be relevant to their projects, which may result in additional cost needed for training in that particular area. Furthermore, not all projects may require the involvement of upstream and downstream processes which makes it difficult to gather all functions together for review meetings.

4.3 Survey Findings

Pearson's correlation analysis is used to evaluate Hypotheses 1 and 2. The results of the correlation analysis are explained in the following sections. The following tables present the results from teamwork in engineering performance. Table 3 presents the correlation analysis used to evaluate *'Hypothesis 1: Quality teamwork correlates with engineering performance in a Malaysian manufacturing firm'*. The Pearson's correlation between quality teamwork and engineering performance is 0.634 with a p value of 0.000. Therefore, the relationship between quality teamwork and engineering performance is positive and significant. Hence, Hypothesis H1 is supported.

Table 3: Quality Teamwork –Engineering Performance Correlation

Test	Output	Interpretation
Pearson's Correlation	0.634***	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 4 presents the correlation analysis used to evaluate *'Hypothesis 2: Cross-functional teamwork correlates with engineering performance in a Malaysian manufacturing firm'*. The Pearson's correlation between cross-functional teamwork and engineering performance is 0.572 with a p value of 0.000. Therefore, the relationship between cross-functional teamwork and engineering performance is positive and significant. Hence, Hypothesis H2 is supported.

Table 4: Cross-Functional Teamwork –Engineering Performance Correlation

Test	Output	Interpretation
Pearson's Correlation	0.572***	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

As explained in the previous section, a multiple linear regression using the stepwise method was conducted to evaluate '*Hypothesis 3 – Knowledge sharing teams influence engineering performance in a Malaysian manufacturing firm'*. However, a few assumptions and conditions need to be satisfied prior to the multiple linear regression analysis.

Tabachnick and Fidell (2001) provide a formula for calculating sample size (N) requirements for regression. They explain that the adequate sample size should be $N > 50 +$ (8 x the number of independent variables). With each individual regression analysis that was conducted the researcher justified the sample size based on this recommendation and the number of variables that were included in the equation. The total number of respondents is 226 while the total number of independent variables tested is 2 (quality teamwork and cross-functional teamwork) for Hypothesis 3. Using the formula provided by Tabachnick and Fidell, the minimum sample size required would be 50 + (8 x 2) or 66 respondents. As such, the sample size criterion is met for this study.

In addition to that, there is a need for the non-existence of multi-collinearity in multiple regression analysis. Multi-collinearity refers to the relationships among the independent variables. Thus, multicollinearity exists when the independent variables are highly correlated at a correlation coefficient (*r*) of 0.9 and above. Correlation matrixes are recommended to be derived prior to regression analysis to test this (Tabachnick and Fidell, 2001).

Pallant (2005, p. 150) suggests to examine for collinearity diagnostics arguing that 'these tests can pick up problems with multi-collinearity that may not be evident by the correlation matrix'. Two outcome variables calculated by the regression analysis are relevant here: the tolerance and variance inflation factor (VIF). 'Tolerance is an indicator of how much of the variability of the specified independent variable is not explained by other independent variables' (Pallant, 2005, p. 150). This value should be greater than 0.1 to justify non existence of multi-collinearity. VIF is the 'inverse of the tolerance value and should be less than 10' (Pallant, 2005, p. 150). All the VIF and tolerance values for the multiple regressions conducted for this study are all within the prescribed range.

Multiple regression analysis is known to be sensitive to outliers. Outliers were sought for from deriving standard residual plots. Those cases having a variable with a standard residual value greater than or equal to |3.3| on the scatter plots, were to be removed prior to running the regression tests (Tabachnick and Fidell, 1996). The standardized residual values for all the regression tests conducted are less than |3.3|.

Regression formulae are based on the assumption that residuals are normally distributed around the predicted dependent variable scores. Normal probability plots were generated to test this. In the normal probability plots, the points should lie in a reasonably straight diagonal line from bottom left to top right, to confirm no major deviations from normality (Pallant, 2005; Tabachnick and Fidell, 1996). In addition to that, the kurtosis and skewness values for the variables tested are within the |1.0| range (Tabachnick and Fidell, 1996).

Having satisfied the assumptions for regression analysis, both independent variables (quality teamwork and cross-functional teamwork) were regressed against engineering performance and the results are summarized in Table 5.

Table 5: Multiple Linear Regression For Engineering Performance

	β	**Std. Error**	***t***	***F***	***R***	**R^2**
	1.712	0.180	9.528***			
mwork	0.376	0.054	0.454***	90.371***	0.669	0.448
ional Teamwork	0.202	0.047	0.279***			

(Notes: * $p<0.05$; ** $p<0.01$; *** $p<0.001$; $N=226$; Durbin Watson = 1.418)

An R^2 of 0.448 was reported with this regression analysis, indicating that 44.8% of the variance in engineering performance is explained by quality and cross-functional teamwork. Table 5 presents the results of the analysis to assert that these variables make a significant contribution (with reported significance levels of less than 0.001) to engineering performance. Quality teamwork proves to be the stronger unique contributor as far as engineering performance is concerned with a reported β of 0.376 while cross-functional teamwork has a β of 0.202. In addition to that, the model is significant as indicated by the ANOVA results of F (2, 223) = 90.371, $p<0.001$. As such, it can be concluded that effective knowledge sharing teams leads to successful engineering performance, thus supporting hypothesis H3.

Based on the correlations, reliability and multiple linear regressions analyses conducted for hypotheses 1, 2 and 3, it can be concluded for correlations analysis that both hypotheses are supported as a significant relationship exists between the independent variables and engineering performance. Also, 44.8% of the variance in engineering performance is explained by quality and cross-functional teamwork.

5. Discussion

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.

5.1 Theoretical Implications

From the results obtained in the study, it is evident that both quality teamwork and cross-functional teamwork have a significant and positive relationship with engineering performance. These findings are relevant and consistent with the literature of quality teamwork as a quality team can help discover and share best-practices throughout an organization by facilitating quality management and yield perfection, improving labour-management communication and improving work satisfaction and the quality of work life for engineers (Cleland and Ireland, 2007).

Also, cross-functional teamwork is proven here to be strongly linked with engineering performance which normally associates itself with superior cost performance, more rapid manufacturing and development timelines (Scott-Young and Samson, 2008). Therefore, there is considerable evidence that quality teamwork and also cross-functional teamwork play a role in improved engineering performance.

However, it is also found that quality teamwork also correlates with engineering performance at a higher value (r=0.634) as compared to that of cross-functional teamwork (r=0.572). The findings suggest that the quality teamwork portrayed in this firm is carried out successfully and is also capable of inspiring engineers, developing engineering performance and self-efficacy (Jun et al., 2006).

As far as cross-functional teamwork is concerned, Susman and Ray (1999) argue that the larger the divergence amongst functions, the larger the obstructions of incorporating these functions on the road to success of a general goal. Their suggestion is relevant with the current study as out of the thousands of workable projects completed in this firm for the past two years, there are bound to be some that are highly complex and involves a larger degree of cross-functional teamwork and collaboration. Thus, higher differentiation among functions will complicate matters in engineering problems and relations among engineers and other technical personnel.

In the multiple linear regression analysis, it was found that 44.8% of the variance in engineering performance is explained by quality and cross-functional teamwork. The analysis also shows that quality teamwork and cross-functional teamwork influences engineering performance in this semiconductor manufacturing firm, implying that knowledge sharing teams, on a whole, play a role in developing engineering performance.

However, the strength of the influence from quality and cross-functional teamwork towards engineering performance seems to be moderate as less than half of the variance in engineering performance is explained by the independent variables involved. This can be proven based on the scale from Johnston (2007) who suggests that a moderate correlation for a model would be between 0.4 to 0.7. In this study, the overall correlation of the framework is given as an R of 0.669. This finding can be explained by Perdomo-Ortiz et al. (2006) who found that greater industrial innovation capability depends not only on quality teamwork but also on training in quality issues, system designs of motivation for excellent jobs and staff selections according to classifications of job proficiency. This finding shows that there are also other variables of influence that need to go hand in hand with teamwork in order to ensure a more improved engineering performance.

A good possible example on the type of variable that can be coupled with teamwork for enhanced engineering performance is leadership. Wang et al. (2005) believe that leadership is critical in all team environments. They emphasize that it is essential for project managers to possess the qualities and skills required towards ensuring the team's achievement This includes abilities in managing employees, pressure, feelings, officialdom and interactions. Thus, there can be a possibility for the level of engineering performance measured in this study to be improved by incorporating leadership together with knowledge sharing.

5.2 Practical Implications

When it comes down to survey findings, the degree of cross-functional teamwork in this firm is displayed to be slightly weaker compared to its quality teamwork. From the results of the survey analyses, it is unmistakable that knowledge sharing teams are more proficient when quality aspects or total quality management aspects are accentuated more in them. However, this does not mean that cross-functional teamwork should be utterly disregarded.
Moreover, according to Fuentes-Fuentes et al. (2004), in environments of higher uncertainty levels, diverse with customer-satisfying actions and rich with resources favourable in terms of growth, quality teamwork among the firm members in cross-functional scopes will be bigger. Therefore, as this firm starts to develop and grow in time, quality teamwork will need to be explored with a larger scale of cross-functional teamwork in engineering teams.

If the firm desires to improve its' cross-functional teamwork capabilities, the leadership and direction of management would be imperative to ensure order and progress in cross-functional engineering teams. In any case, cross-functional teamwork would incorporate development via organizational and information management processes in an encouraging supervisory and directorial atmosphere (Abdalla, 1999). Without proper leadership or management support, there can be no guarantee that cross-functional teamwork will be a success as far as engineering performance is concerned.

From the interview findings, it is clearly noted as well that quality teamwork among engineering teams in individual departments are relatively strong. Barriers still exist among departments, which cause cross-functional teamwork to be at a weaker position as compared to quality teamwork. Moreover, job scopes of engineers that are defined improperly with respect to their fields of expertise can impair the performance of the engineers.

Furthermore, due to the nature of this industry, it would not be easy to involve different engineers at different stages of the project life cycle, such as getting other functions to be involved at the early stage of development. This is due to the complexity and structure of the processes that are long and complicated. Haque et al. (2003) posit that the key barrier to the triumph of cross-functional teamwork often was the poor partaking and dedication of team members, predominantly the major product development group. From this suggestion, it is evidently observed that if the firm desires to improve its cross-functional relations among teams, knowledge sharing barriers among teams from different divisions will have to be eliminated.

One of the proposals to help improve cross-functional teamwork in this firm would be to cluster the projects under a specialized project group that is multidisciplinary in nature and label them as project teams. This action would possibly improve the relations among team members geared towards a similar goal in completing projects. In any case, Cordero et al. (1998) also suggest that technical professionals who work on project teams interact more with other functions and experience more teamwork than technical professionals who work on research and development groups. Thus, a solution to form a specified project group will eliminate barriers in knowledge sharing among team members and cultivate cross-functional teamwork.

6. Conclusion

All in all, quality teamwork is demonstrably a more dominant form of teamwork in the context of this particular semiconductor manufacturing firm. This can be due to various reasons which includes the environment context portrayed in the firm or also the type of innovation in which the engineering projects are carried out. Nevertheless, it is imperative for the firm to find more solutions in improving its' cross-functional teamwork capabilities in order to bring their engineering performance to a higher, more advanced and improved level.

This study provided statistical support that cross-functional teamwork may be an area which is lacking and impeding the performance of engineers. The interview findings from this study provided substantiation that this lacking was due to poorly distributed job scopes which were not according to the field of expertise of the engineers. Also, the attitude of engineers who are unwilling to cooperate among each other cause barriers to exist and thus, projects to be delayed. In order for engineering performance to be enhanced to its optimum level, the firm will need to focus on ways to cultivate knowledge sharing among departments and functions.

Overall, the teamwork displayed in this firm is satisfactory but not at an outstanding level judging from its engineering performance. The possible ways to improve engineering performance would be to enhance the cross-functional teamwork which is lacking in the firm and also to consider other influential variables that promote engineering performance, such as leadership.

This study also consists of some limitations, owing to the fact that the context of the study was within a single manufacturing firm and cannot be generalized beyond the context of that particular firm. Nevertheless, the richness of information in the interview and comprehensive survey data is undoubtedly useful for managers, engineers and researchers as it provides insights on specific areas that require adequate attention to ensure effective engineering performance.

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