

CAUSAL RELATIONSHIPS BETWEEN ENABLERS OF CONSTRUCTION SAFETY CULTURE

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Abstract

Better understanding of safety culture and causal relationships between its key elements is a must for construction organizations to strategically allocate their safety resources. This paper reports the use of structural equation modelling (SEM) technique to test causal relationships between key elements of construction safety culture. These elements (five enablers and goals) were identified through the utilisation of the widely used EFQM Excellence Model. Data gathered via a questionnaire survey were analysed using SEM. The statistical results appear to support the hypothesized positive relationships between five enablers and goals. Moreover, the analysis reveals that the “people” enabler has a positive effect on other enablers such as “partnerships and resources” and “processes”. The study findings highlight the interaction among the five enablers thus guiding construction organizations to identify which enabler(s) has the potential to maximize returns on their safety resource investment in order to achieve predetermined goals of the overall health and safety performance.

Keywords

Construction Safety Culture, Enablers, Goals, Structural Equation Modelling

1 INTRODUCTION

The construction industry is characterised as one with a poor safety culture and that attempts to improve the safety record will not be fully effective until the safety culture is improved (Blockley, 1995). Better understanding of safety culture, and its key determinants (enablers), will definitely help construction organizations to strategically allocate resources and concentrate their efforts in order to improve their overall safety performance. Many research studies have investigated the nature of construction safety culture focusing mainly on its characteristics, attributes, key success factors and assessment. Molenaar *et al.* (2002) identified a total of 31 characteristics that define organizational safety culture including management commitment, communication, strategy development and implementation, resources, empowerment, to name but a few. Wright *et al.* (1999) developed a safety culture improvement matrix to be used as a self-assessment tool. Mohamed (2003) adopted the Balanced Scorecard tool to assess and benchmark organizational safety culture, and argued that a performance measurement tool which has a number of different but complementary perspectives would enable organizations to pursue incremental safety performance improvements.

Despite the growing body of construction safety culture literature, it is still widely recognized that the empirical validation of how its key enablers are inter-related is limited, and it is mostly based on studies that test isolated associations. The interactions between what the organization is doing (enablers) and what it aims to achieve (goals) appear to be ignored (Mohamed and Chinda, 2005). Moreover, the causal links between those enablers and goals have not been properly addressed (Chinda and Mohamed, 2006). This paper aims to verify the causal relationships and interactions between the enablers and goals of construction safety culture, thus providing a greater understanding of their inter-dependence which, in turn, facilitates safety performance improvement.

To achieve the above research objective, a conceptual model was hypothesised based on the logical assumption that by improving how the organization operates, there will be an inevitable improvement in the results. This same assumption underlies the most commonly applied model for total quality management (TQM) known as the EFQM (European Foundation for Quality Management) Excellence model. Empirical evidence suggests that the application of holistic management models, such as the EFQM Excellence model, has a positive effect on organizational performance (Kristensen and Juhl, 1999). The statistical technique of structural equation modelling (SEM) was used in this study to gain insights into the interactions and associations among the different enablers of the model.

2 THE EFQM EXCELLENCE MODEL

The EFQM Excellence model consists of nine elements grouped under five ‘enablers’ criteria namely *Leadership (Lds)*, *Policy and Strategy (Pol)*, *People (Ppl)*, *Partnerships and Resources (Prs)* and *Processes (Pro)* as well as four ‘results’ criteria including *People*, *Customer*, *Society* and *Key Performance* results. The enablers represent how the organization operates, and the results concentrate on achieving predetermined organizational goals. In the study, however, the focus has been mainly on the improvements of enablers’ criteria in order to achieve better results, so that the four ‘results’ criteria are combined together into a single construct – called hereinafter *Goals*. In the EFQM Excellence model, it is assumed that *Lds* drives *Ppl* management, *Pol* and *Prs*, and these three enablers collectively influence the ability to achieve pre-determined *Goals* through the implementation and improvement of suitable *Pro*. Based on the literature review, the five enablers with their 27 attributes, and the single goals with its seven associated attributes were hypothesized as shown in Figure 1 where the ovals and rectangles symbolize latent and observed variables, respectively. The former represent the six constructs of the model, whereas the latter represent their respective attributes. The arrows connecting the two sets of variables indicate the direction of the hypothesized influence. For example, it is hypothesized that *Lds* is manifested by the achievement of its four attributes namely; commitment, communication, accountability and leading by example, thus the arrows are shown originating from *Lds* to each one of the four attributes.

In this study, two statistical analyses were used to empirically test the hypothetical model. An exploratory factor analysis (EFA) was conducted using SPSS software to check the appropriateness of the proposed grouping of attributes under the six constructs listed in Figure 1. This was followed by the application of structural equation modelling (SEM), using Amos 4.0 software, to investigate the inter-relationships between the six constructs. The use of SEM in this study was justified to avoid excessive multi-collinearity that could have resulted if another statistical technique such as multiple regression was used. Multi-collinearity which leads to bias and unstable findings was thought to exist due to the expected inter-correlations among predictors within the model’s constructs.

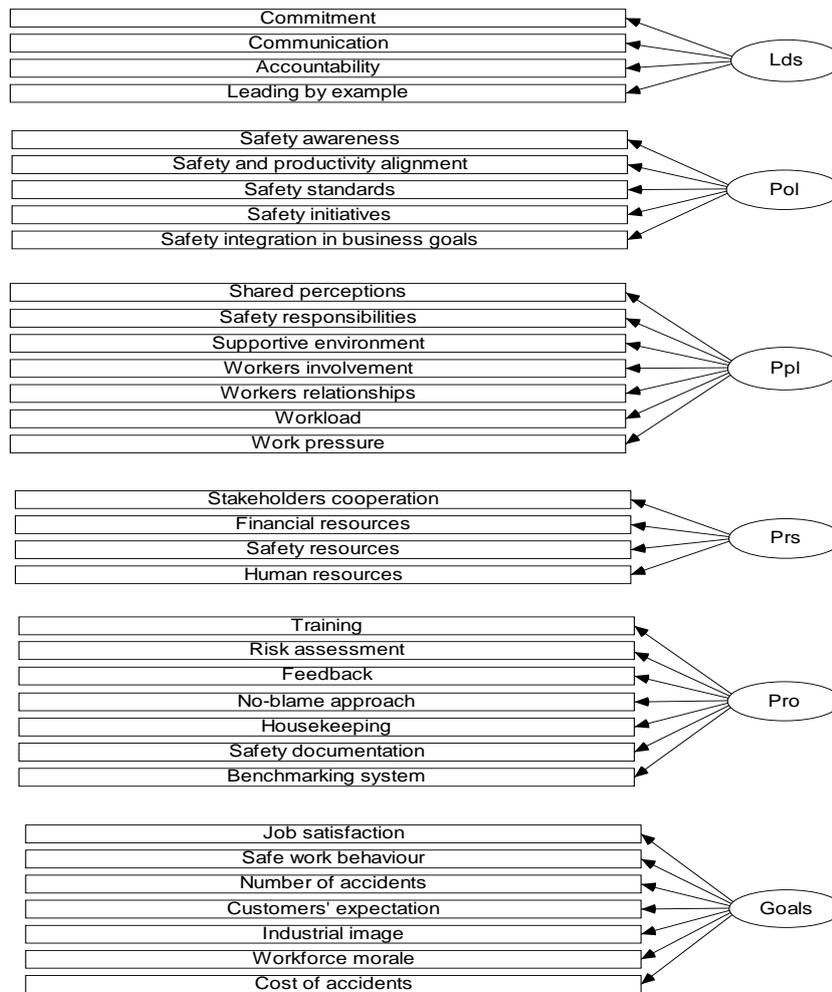


Figure 1: Hypothetical Model of Construction Safety Culture

3 EXPLORATORY FACTOR ANALYSIS (EFA)

Principal axis factoring, with the varimax rotation method, was used to examine the dimensionality of the safety culture enablers' attributes, and for better interpretability of factor loadings. According to our sample size, a cut-off factor loading of 0.45 has been used to screen out items that are weak indicators of the constructs (Hair *et al.*, 1998). Two problematic items – having ‘*no-blame approach*’ and ‘*shared perceptions*’ – failed to make this cut-off and were consequently dropped from the data file. Based on eigenvalues greater than 1, the EFA of the remaining 25 items extracted three factors accounting for 59.73% of the total variance. Factor 1 was predominantly accounted for by nine items initially measuring *Pro* and *Prs*; Factor 2 by 10 items initially measuring *Lds* and *Pol* and Factor 3 by six items initially measuring *Ppl* and *Prs*. Closer examination of the identified factors revealed potential for further analysis to extract independent factors in line with those of the proposed model. Accordingly, it was decided to further factor-analyze the three factors, setting their required extraction limit to two new factors each. As a result, the nine items of Factor 1 gave rise to two new factors accounting for 62.58% of the total variance. Similarly, two factors were extracted from the nine items (the ‘*supportive environment*’ item failed to make the cut-off factor loading of 0.45) of Factor 2 accounting for 59.10% of the total variance. However, no new factors were extracted from the analysis of Factor 3. As a result, five underlying

factors, represented by 24 items, were extracted. It is worth pointing out that the above analysis has led nine items initially assumed to be associated with a certain enabler, to strongly correlate with another enabler, as shown in Figure 2 with ‘*’ sign. Following the re-allocation of the nine items, the Cronbach’s alpha (α) reliability test was applied to ensure the appropriateness of groupings of five factors extracted. The value of 0.7 is generally accepted as the minimum desired value of the α coefficient (Pallant, 2005). The results showed that the reliability coefficients range from 0.85 to 0.90, hence all of which were considered acceptable. In sum, the EFA gave rise to a total of 24 attributes grouped to explain five latent factors (i.e. enablers), whereas a total of seven attributes were grouped to explain a sixth latent factor (i.e. goals). Accordingly, the hypothesised model of construction safety culture was modified, leading to the baseline model shown in Figure 2.

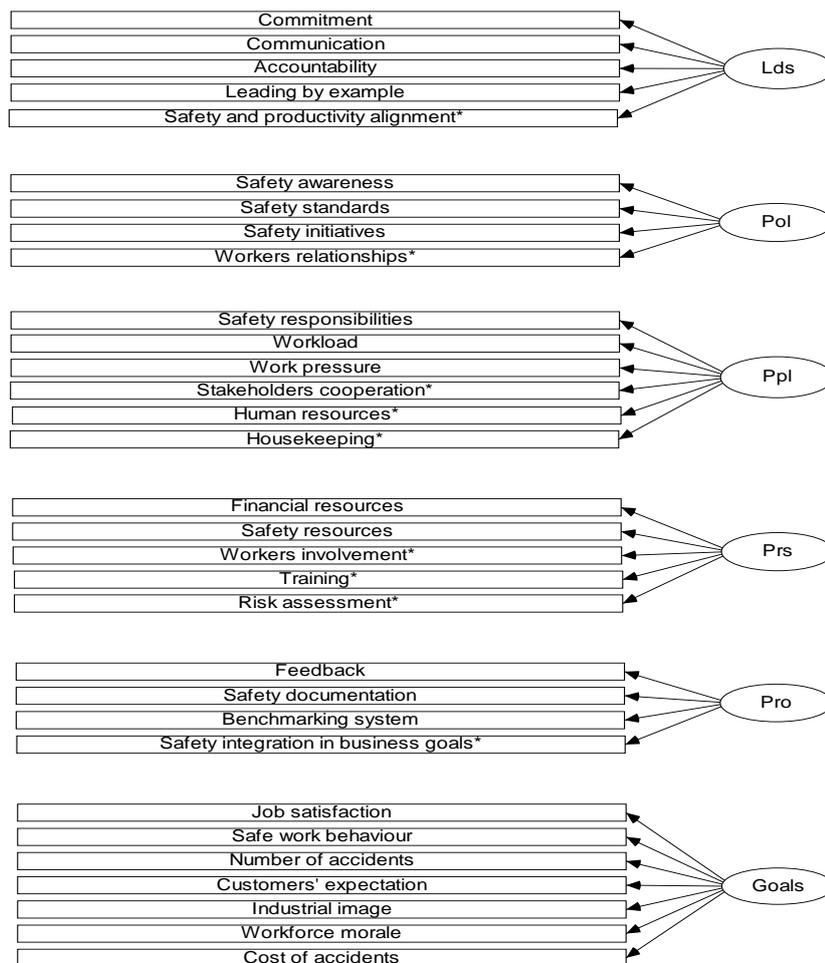


Figure 2: Baseline Model of Construction Safety Culture

4 STRUCTURAL EQUATION MODELLING (SEM)

Theoretically, SEM comprises two types of models: a measurement model and a structural model. The former is concerned with how well the variables measure the latent factors addressing their reliability and validity, and the latter is concerned with modelling the relationships between the latent factors by describing the amount of explained and unexplained variance, which is akin to the system of

simultaneous regression models (Wong and Cheung, 2005). Testing the structural model would be meaningless until it has been established as a good measurement model. In this study, a confirmatory factor analysis (CFA) was conducted in order to establish confidence in the measurement model which specifies the posited relations of the observed variables to the underlying constructs. A critical issue in relation to CFA is the assessment of the overall model fit. The overall fit of our baseline model was assessed using multiple goodness-of-fit (GOF) indices which include χ^2/DF , RMSEA, CFI and IFI. The baseline model was analyzed using the Amos 4.0 program (Arbuckle and Wothke, 1999). Two modification options were used to improve model fit (Kline, 2005). The first option of eliminating links or ‘paths’ with very low correlations was not applicable to our baseline model. The second option was to remove the observed variables shown by the computed modification indices as having multi-collinearity. In so doing, a total of seven observed variables were deleted, three from *Ppl*, one from *Prs* and three from *Goals*. Further modifications did not improve the model fit thus leading to the best-fit measurement model with GOF indices shown in Figure 3 and Table 1, respectively. All path coefficients of the best-fit measurement model are positive and statistically significant at $p < 0.05$, thus confirming that their significance to the model is augmented. Moreover, most of the R^2 of the observed variables were greater than 0.50 indicating reasonably good convergent validity of the model.

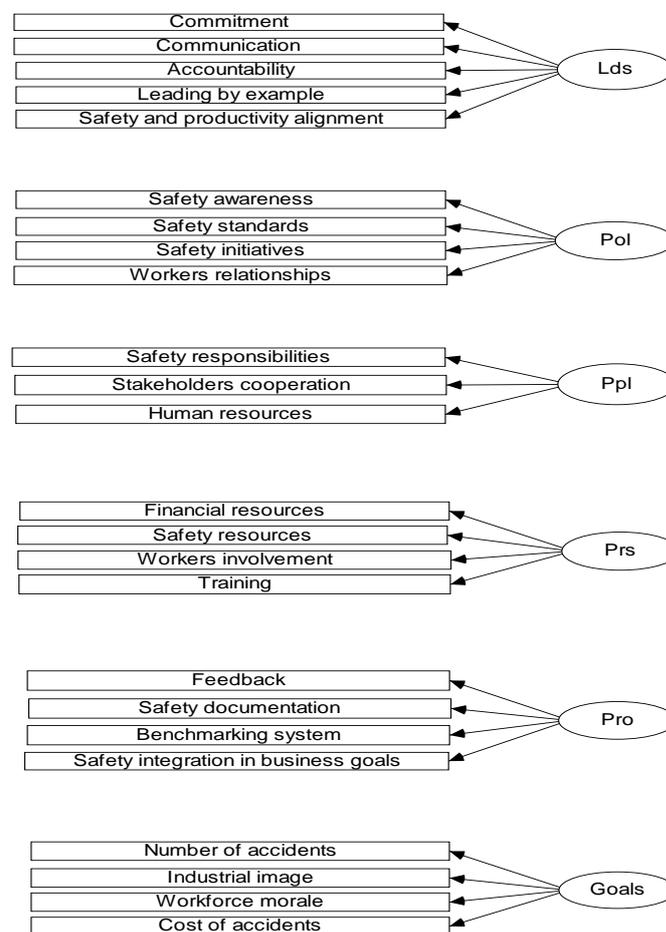


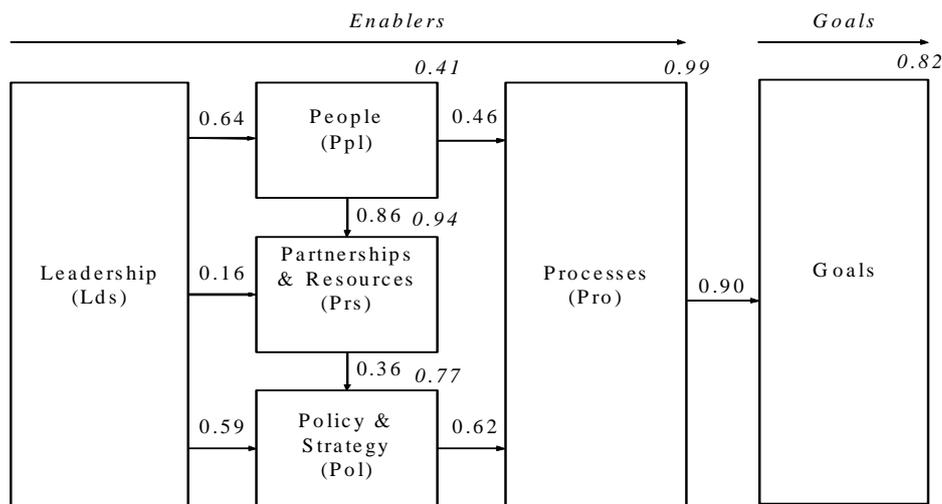
Figure 3: The Best-Fit Measurement Model

Having established confidence in the measurement model, a structural model was developed and tested to examine the direction of assumed relationships between the six latent variables as reflected by the arrows connecting them.

Table 1: GOF Indices

Fit Indices	Recommended Level	Baseline Model	Fitted Measurement Model	Fitted Structural Model
χ^2/DF	< 2.00 (Byrne, 2001)	2.10	1.65	1.68
CFI	> 0.90 (Kline, 2005)	0.82	0.91	0.91
IFI	> 0.90 (Kline, 2005)	0.82	0.91	0.91
RMSEA	≤ 0.10 (Byrne, 2001)	0.10	0.07	0.07

A fundamental feature of any SEM is the direction of the arrows denoting the direction of the assumed relationships between variables as explained below. In our model, the arrows were assumed to support the argument that *Lds* drives (influences) three enablers namely, *Pol*, *Ppl* and *Prs*, and these three enablers collectively influence the ability to achieve pre-determined *Goals* through the implementation and improvement of suitable *Pro*. As a starting point, bi-directional arrows were used to represent relationships among the three enablers, *Pol*, *Ppl* and *Prs*, without an explicitly defined causal direction. This is because of the variables' potential to affect each other. For example, *Pol* might influence *Ppl*, and/or vice versa. To explore this relationship further, and to improve the overall model fit, a number of model runs (with different arrow directions connecting those three enablers) were carried out. Any links with very low correlations, or items showing signs of multi-collinearity were deleted. For each run, GOF indices were computed and compared. According to Clissold (2004), the model with the best fit should prove the directional influences. The fitted model, with the GOF indices listed in Table 1, was deemed to be the final model of construction safety culture, see Figures 4. This model confirmed that *Pro* has a significant direct relationship with *Goals* (with path coefficient = 0.90), and *Pro* explains and influences 82% of the variance in *Goals*.



Note: The italic numbers show variance values (R^2) of the factors

Figure 4: Final Model of Construction Safety Culture

As previously mentioned, the value of SEM lies in its ability to depict both direct and indirect effects between the variables. In light of this, the best-fit model appears to indicate that *Ppl* strongly influences *Prs*, whereas *Prs* moderately influences *Pol*. Both *Ppl* and *Pol* were found having significant direct relationships with *Pro* (with path coefficient = 0.46 and 0.62, respectively) at 0.05 probability level. No statistically significant relationship, however, was found between *Prs* and *Pro*, indicating the absence of direct effect. An indirect effect, though, exists through *Pol*. *Prs* was found having a positive impact on *Pol* (path coefficient = 0.36) which, in turn, influences *Pro*. It is worth noting that R^2 for *Pro* is 0.99 demonstrating that 99% of the variance associated with *Pro* is accounted for by its two predictors namely

Ppl and *Pol*. *Lds* shows significant direct relationship with *Ppl* (path coefficient = 0.64) and *Pol* (path coefficient = 0.59) but surprisingly bears no statistically significant relationship with *Prs*. The relatively strong influence *Ppl* has on *Prs* (path coefficient = 0.86) suggests that *Lds* indirectly influences *Prs* through *Ppl*. The summary of direct and indirect path coefficients, together with the values of R^2 between the five enablers and goals is shown in Table 2.

Table 2: Direct and Indirect Path Coefficients between Enablers and Goals

Latent Factor	Correlation Coefficient	R^2
People	$0.64 * Lds$	0.41
Partnerships and Resources	$0.16 * Lds + 0.86 * Ppl + (0.55 * Lds * Ppl)$	0.94
Policy and Strategy	$0.59 * Lds + 0.36 * Prs + (0.31 * Ppl * Prs)$	0.77
Processes	$0.46 * Ppl + 0.62 * Pol + (0.29 * Lds * Ppl) + (0.37 * Lds * Pol) + (0.22 * Prs * Pol)$	0.99
Goals	$0.90 * Pro + (0.41 * Ppl * Pro) + (0.56 * Pol * Pro)$	0.82

5 DISCUSSION AND CONCLUSION

This study examined the interactions between the key elements of safety culture (enablers and goals). The statistical results confirm the existence of a very strong relationship between *Pro* and *Goals* implying that excellent safety outcome (i.e. reduced number and cost of accidents, higher work morale and enhanced industry image) can only be achieved through rigour implementation of safety related processes which appears to be directly related to *Ppl* and *Pol*, and not to *Prs*. This finding is consistent, to some extent, with that of recent process management studies (Eskildsen and Dahlgard, 2000) where process management was found to be directly related to strategic planning and human resources management. Although in our model, *Prs* did not have a significant direct effect on *Pro*, they did, however, have a significant indirect effect through its influence on *Pol*. This is in line with the recommendations by Wright *et al.* (1999), which imply that resource requirements are a fundamental element in formulating effective policies to improve safety process implementation. The results also show that *Ppl* has an indirect relationship with *Pol* through *Prs*. This relationship supports earlier statements by Pipitsupaphol and Watanabe (2000) who investigated the root causes of accidents in the Thai construction industry and concluded that workers must be provided with adequate safety resources to facilitate performing the job safely. In doing so, it is not difficult to see the explicit impact of resources requirement on the development of policies for improving safety performance.

Interestingly, *Lds* has a relatively weak direct effect on *Prs*. It appears that most of its influence on this particular enabler is mediated through *Ppl* enabler. This indirect effect corroborates well with the overall perception of Thai construction managers where human resources and teamwork are believed to be more crucial to successful safety implementation than the provision of safety resources (Aksorn and Hadikusumo, 2006). The obtained direct relationship between *Lds* and *Ppl* in the model underpins the widely accepted role leadership plays in changing workers behaviour through demonstrating strong commitment and accountability towards safety. The psychological link between management presence on site and workers safe behaviour (Little, 2002), gives rise to a good perception about safety, hence getting workers to accept more safety responsibilities (Siu *et al.*, 2004). This in turn exerts extra pressure on resources as indicated by the strong correlation, in the model, between the *Ppl* and *Prs* enablers. *Lds* also has an indirect relationship with *Pro* through the mediating effects on *Ppl* and *Pol*. This confirms that *Lds* plays an important role in driving the success of safety culture in the organization. There is a limitation in this research study. The proposed model has been validated by collecting data from large construction organizations in Thailand. Due to this fact, and the self-reported method of data collection, there is a possibility of bias playing role in the final outcome of the study. Nevertheless, this study offers support for the proposed conceptual model and empirical basis for comparison in future research.

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