Exploratory Factor Analysis of Safety Culture in Thai Construction Industry

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Abstract

Construction industry is unique and complex compared with other industries. It contains a wide range of construction materials and products, building services manufactures, contractors, sub-contractors, design, operation, and refurbishment services. These complexities make the industry as one of the most hazardous industries that causes high rate of accidents. To reduce this accident rate and improve safety performance, safety culture must be considered. This paper, thus, aims at investigating the key factors (enablers) representing safety culture improvement in Thai construction industry using the exploratory factor analysis. The generalized least squares method, together with the eigenvalue over 1, factor loading of 0.4, and varimax rotation, are used to extract the key enablers from the 27 attributes. The final results reveal five key enablers, namely Leadership, People, Partnerships and Resources, Policy and Strategy, and Processes, with a total of 25 associated attributes. The five enablers can be used as a guideline for safety culture improvement.

Keywords: construction, enabler, factor analysis, safety culture

Construction Industry

A number of unique characteristics distinguish the construction industry from other industries. For example, the construction projects are operated under time and budget pressures, with high amount of temporary workers with various skills. The projects are also influenced by weather conditions and external environments (Andi, 2008). Dester and Blockley (1995) stated that to improve safety record and reduce number of accidents, safety culture must be considered. Since, poor safety record can be recognized as a consequent of poor safety culture, there are a growing number of studies on safety culture.

Safety Culture

According to Mearns et al. (1998), safety culture is defined as the attitudes, values, norms and beliefs which a particular group of people share with respect to risk and safety. Good safety culture can help controlling and reducing the construction costs and increase efficient of operating as stated by Fung et al. (2005). To improve safety culture, it is important to understand the key factors influencing safety culture improvement. This paper, thus, aims at

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investigating the key factors representing safety culture improvement in Thai construction industry. European Foundation for Quality Management (EFQM) is used as a basic model for safety culture development.

The EFQM Excellence Model

The EFQM Excellence model is a non-prescriptive framework which consists of two parts, enablers and results. The enablers' part covers what organization does, and composes of five criteria, which are Leadership (L), People (H), Policy and Strategy (S), Partnerships and Resources (R), and Processes (P). The results' part on the other hand covers what the organization achieves, and consists of four criteria, including People Results, Customer Results, Society Results and Key Performance Results, (as shown in Figure 1).

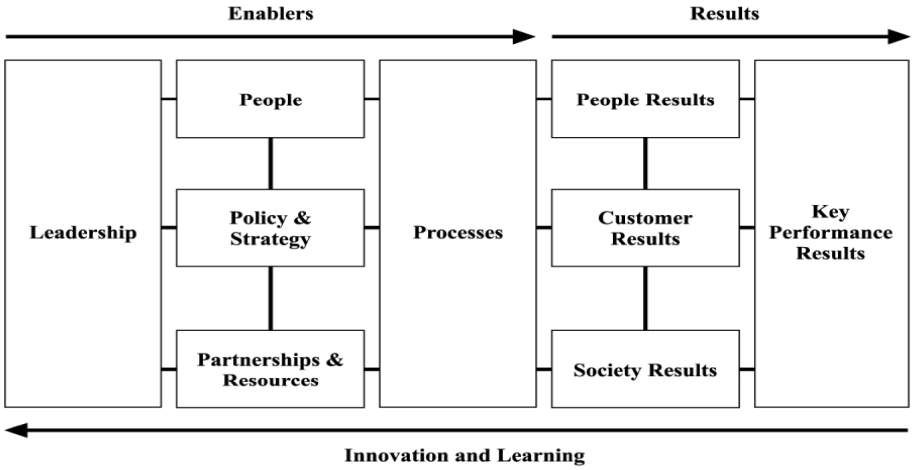

Figure 1. EFQM Excellence Model (EFQM/BQM, 2003)

The EFQM Excellence model is selected as a basic model for safety culture development due to its applications in many fields of studies, including construction industry (British Quality Foundation, 2003; Fung et al., 2005; NuSAC, 2005; Vallejo et al., 2006). The model is used for measuring the strength and areas where the improvement can be achieved. The model consists of two parts, five enablers and four results; however, the focus in this study is on the five enablers' as it believes that the better implementation of the enablers gives better results. This is seen by the arrows pointing from enablers to results (see Figure1). Each enabler consists of a number of its associated attributes to explain its construct. The details are explained next.

Leadership

Leadership, the first enabler, consists of five attributes to explain its construct. The details of each attribute are described below:

1. *Commitment* (LCOM): A successful changing of safety culture requires clear management commitment throughout the organizations (Akiner and Tijhuis, 2008).
2. *Consultative style* (LCST): Hinze and Parker (1978) suggested that good safety performance and high productivity are linked to management consultative style.

3. *Encouragement* (LENC): Safety managers should see their function as a management resource dedicated to helping and encouraging all members of the company to create and cultivate a safe and healthy workplace (Dilley and Kleiner, 1996).
4. *Role model* (LROL): Langford et al. (2000) indicated that supervisors, who have positive safe behavior and are a role model in safety, influence positive operatives' attitudes.
5. *Safety accountability* (LACC): To develop positive safety cultures, senior managers should allocate their safety responsibility throughout the project organization from senior down to various team members (Lingard, 2009).

People

People enabler consists of six attributes as detailed below.

1. *Peer review* (HPRV): To create a safety environment, the employees should care about safety, not only for themselves, but also for others (Geller et al., 1996).
2. *Safety awareness* (HAWN): Dilley and Kleiner (1996) suggested that creating a culture of safety means that the employees are constantly aware of hazards in the workplace, including the ones that they create themselves.
3. *Safety empowerment* (HEMP): It becomes second nature to the employees to take steps to improve safety. When employees take their safety responsibility, safety culture increases (Dilley and Kleiner, 1996).
4. *Workers' competence* (HWCO): Andi (2008) stated that workers with adequate safety knowledge, skills and ability are likely to minimize accidents.
5. *Workers' involvement* (HINV): Higher level of workers involvement will give positive influence to safety behavior (Andi, 2008).
6. *Work pressure* (HPRE): Hinze and Parker (1978) concluded that excessive pressures by company head office on site superintendents, and by superintendents on the labor force, are likely to increase injury frequency and reduce production.

Policy and Strategy

Four attributes are associated with Policy and Strategy enabler, which are:

1. *National safety law* (SNAT): Langford et al. (2000) claimed that safety laws and regulations are a part of safety's infrastructure.
2. *Reward system* (SRWD): Reward systems that compensate workers for safe working, whilst achieving desired levels of productivity, are required (Langford et al., 2000).
3. *Safety audit strategy* (SAUD): Dester and Blockley (1995) suggested that audits of unsafe acts should be used in a way that goes beyond the straightforward audit-corrective action process, but as a part of safety improvement policy.
4. *Safety rules and procedure* (SRUL): A clear safety rules and procedures facilitated positive safety culture (Andi, 2008).

Partnerships and Resources

Four attributes are extracted to explain Partnerships and Resources enabler.

1. *Stakeholders' collaboration* (RCOL): Lingard (2009) stated that success in occupational health and safety management can only be achieved through teamwork, especially with the project stakeholders (i.e. the clients and the contractors).
2. *Human resources* (RHRS): Abudayyeh et al. (2006) claimed that adequate, as well as capable (skill), workers are required for effective safety program.
3. *Provision of personal safety equipment* (RPSE): The adequately provision of safety equipment and personal protective equipment are prerequisites for improved safety performance (Langford et al., 2000).
4. *Provision of safety document* (RPSD): Every worker should be provided with a safety booklet to be used as a guideline for safety improvement (Langford et al., 2000).

Processes

Lastly, Processes enabler consists of eight attributes, as described below.

1. *Accident investigation* (PAIN): Oklahoma Department of Labor (2009) suggested that accident investigation helps determining the causes of accidents, thus enhancing the organizational learning.
2. *Benchmarking* (PBEN): Having a benchmark system of safety on site helps improving safety performance (Lingard, 2009).
3. *Job clarity* (PJCL): Hemingway and Smith (1999) stated that a lack of job clarity may have a direct effect on injuries, as this leads to the individual operating in unfamiliar situations, thus, increasing the likelihood of accidents.
4. *Housekeeping* (PHKP): Suitable mechanical plant on site is a recipe for safety (Langford et al., 2000).
5. *Feedback* (PFED): Safety performance is enhanced when clear feedback of safety performance-related information is provided (Algera, 1990).
6. *Risk assessment* (PRAS): BarBl (1997) suggested that the risk assessment should be performed industry by industry, and protective measures should be provided.
7. *Safety data collection* (PDCO): The inadequacy of the safety data collection leads to the lack of focus in safety campaigns and inability to measure the effectiveness of their efforts (Chan et al., 2004).
8. *Training* (PTRA): Training can about to motivate and assist workers to work more safely by in safety context (Langford et al., 2000).

The above 27 attributes explain the five enablers in safety context. These attributes are then used in the questionnaire development for data collection.

Questionnaire Survey and Preliminary Analyses

The questionnaire survey is developed based on the extracted 27 attributes. A total of 800 questionnaires have been launched to the construction companies with 548 returns, representing 68.5% in the respond rate. From the returned responses, 138 are unusable due to data incompleteness, resulting in a total of 410 questionnaires for further analyses. More than half of the respondents have high working experiences, and involve in safety related activities. This gives confidence in the suitability of the responses in reflecting the correct practices in Thai construction industry. To further increase the confidence in the data collected, a number of preliminary analyses are performed, including the normality test (i.e. testing skewness and kurtosis), the outlier test (i.e. the 5% trimmed mean and z-score tests), and the reliability test. The normality test indicates the suitability of the data set. However, the outlier test shows

seven problematic attributes included in questionnaire numbers 38, 98,130, 160, 317, 384, and 392. Therefore, these seven data sets are deleted from data file and are not used for further analyses. The remaining 403 data set are used for reliability test, the results show that all five enablers have higher alpha value than the minimum value of 0.7 (see Table 3). However, it is found that the alphas if item deleted of the LCST, HINV, HPRE, and SRUL attributes are higher than those of their group values, showing that the stated attributes might not belong to their respective groups; this thus, needs further investigation. The confirmed 27 attributes, within five enablers, are then performed with exploratory factor analysis (EFA) to confirm the construct validity of those five enablers. The details are explained next.

Exploratory Factor Analysis

The EFA is employed to confirm the five safety culture enablers with a total of 27 attributes. The generalized least squares method, together with the eigenvalue over 1, factor loading of 0.4, and varimax rotation are used to perform the EFA (Raubenheimer, 2004; Garson, 2009). The first run gives the results as shown in Table 1.

Table 1. Factor analysis results of the 27 attributes

Attribute	Factor				
	1	2	3	4	5
PDCO	0.750				
PRAS	0.702				
PAIN	0.685				
PJCL	0.665				
PFED	0.621				
PBEN	0.606				
PTRA	0.569				
PHKP	0.463				
SAUD	0.427				
SRWD	0.408				
SRUL					
HINV					
HWCO		0.731			
HEMP		0.727			
HPRV		0.655			
HAWN		0.651			
LENC			0.721		
LROL			0.703		
LCOM			0.582		
LACC			0.564		
HPRE			0.560		
LCST			0.488		
RPSD				0.711	
RHRS				0.564	
RPSE				0.514	
RCOL				0.468	
SNAT					0.646

Factor loadings of the SRUL and the HINV are less than the minimum value of 0.4 (see Table 1); therefore, they are deleted from the data file. The second run of the remaining 25 attributes gives the results as illustrated in Table 2.

Table 2**.** Factor analysis results of the 25 attributes

Attribute	**Factor**				
	1	**2**	**3**	**4**	**5**
PDCO	0.741				
PRAS	0.703				
PAIN	0.687				
PJCL	0.657				
PFED	0.604				
PBEN	0.592				
PTRA	0.557				
PHKP	0.460				
HEMP		0.742			
HWCO		0.723			
HAWN		0.661			
HPRV		0.635			
LENC			0.731		
LROL			0.706		
LCOM			0.592		
HPRE*			0.566		
LACC			0.545		
LCST			0.490		
RPSD				0.702	
RHRS				0.583	
RPSE				0.514	
RCOL				0.470	
SNAT					0.537
SRWD					0.475
SAUD					0.446

Note: *Item relocated to another enabler.

As shown in Table 2, the 25 attributes are extracted into five enablers, in which the attributes in each enabler represents the characteristics of their respective enabler. Factor 1 consists of eight attributes that explain mainly on process, thus, it is called Process enabler. Factor 2 illustrates mainly on people, hence, it is called People enabler. Factor 3 consists of six attributes; most of them relate to leadership, therefore, it is called Leadership enabler. The HPRE attribute, however, is relocated to Leadership enabler, where, it is originally located in People enabler. The relocation of HPRE is supported by Langford et al. (2000), who stated that supervisors (management level) are likely to turn a blind eye to unsafe practices on a site due to the pressure in order to achieve targets set by agreed-upon programs. This, in turn, leads to high risks of accidents. Factor 4 covers four attributes described mainly on partnerships and resources, therefore, it is called Partnerships and Resources enabler. Lastly, eight attributes are grouped in Factor 5 and that they explain mainly on policy and strategy thus it s called Policy and Strategy enabler.

These five enablers are next examined with the reliability test to further confirm their construct. The results are illustrated in the following table.

Table 3. Reliability test

Initial Reliability Test			Final Reliability Test		
Enabler	**Alpha**	**Alpha if item deleted**	**Enabler**	**Alpha**	**Alpha if Item deleted**
Leadership	0.808			0.836	
• LCOM		0.761	• LCOM		0.799
• **LCST***		0.815	• LCST		0.839
• LENC		0.744	• LENC		0.793
• LROL		0.747	• LROL		0.793
• LACC		0.789	• LACC		0.822
			• **HPRE****		0.808
People	0.827			0.854	
• HPRV		0.783	• HPRV		0.825
• HAWN		0.784	• HAWN		0.818
• HEMP		0.781	• HEMP		0.808
• HWCO		0.779	• HWCO		0.808
• **HINV***		0.833			
• **HPRE***		0.828			
Policy and Strategy	0.819			0.830	
• SNAT		0.733	• SNAT		0.748
• SRWD		0.754	• SRWD		0.748
• SAUD		0.775	• SAUD		0.798
• **SRUL***		0.830			
Partnerships and Resources	0.827			0.827	
• RCOL		0.803	• RCOL		0.803
• PHRS		0.768	• PHRS		0.768
• RPSE		0.790	• RPSE		0.790
• RPSD		0.763	• RPSD		0.763
Process	0.906			0.906	
• PAIN		0.892	• PAIN		0.892
• PBEN		0.893	• PBEN		0.893
• PJCL		0.893	• PJCL		0.893
• PHKP		0.900	• PHKP		0.900
• PFED		0.894	• PFED		0.894
• PRAS		0.892	• PRAS		0.892
• PDCO		0.889	• PDCO		0.889
• PTRA		0.894	• PTRA		0.894

Note: *Items having the alpha value if item deleted higher than their group values. **Item relocated to another enabler.

It is obvious, that the new alpha values of all five enablers are at least the same, or even better than, their original values. Also the relocation of the HPRE from People enabler to Leadership enabler results in higher alpha value for both enabler, proving the suitable of the relocation of the HRRE. Moreover, the HINV and SRUL attributes are also deleted during the analysis process, resulting in higher alpha values for both People and Policy and Strategy enablers.

Conclusion

The construction industry has a poor safety record, and safety culture is an important role in improving safety in this industry. This paper investigates the key factors (enablers) for safety culture improvement in Thai construction industry. A number of safety-related attributes are extracted from a number of construction-related literature reviews. The extraction of attributes is classified based on one of the widely used quality model, the EFQM Excellence model. A total of 410 data sets based on total of 27 attributes are achieved through questionnaire survey. Preliminary analyses are then performed to screen the data, and as a result, 7 data sets are deleted, leading the 403 data sets for the EFA.

The general least square method, together with eigenvalue over 1, factor loading of 0.4, and varimax rotation, are used to perform the EFA. Two attributes, including 'safety rules and procedure' (SRUL) and 'workers' involvement' (HINV), are deleted from the data file as they do not pass the cut off factor loading. The remaining 25 attributes are divided into five factors, including Leadership, People, Partnerships and Resources, Policy and Strategy, and Processes. The reliability test confirms these five enablers with their associated attributes.

The five enablers can be used as a guideline for safety culture improvement. Leaders, for example, should commit more on safety, open more on safety suggestions, provide proper safety accountability to all workers, and behave as a role model in safety implementation.

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