INFLUENCE OF TECHNICAL SKILL ON SAFETY TASK IMPLEMENTATION AND SAFETY CLIMATE DEVELOPMENT IN CONSTRUCTION

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One of the essential skills needed by project personnel to manage construction safety is technical skill, which may consist of scheduling, budgeting, quality management, document management, risk management, and procurement management skills. This research aims to investigate how technical skill may influence safety performance. Quantitative data (N=273) were collected and analysed using structural equation modelling (SEM) technique. It was found that document management and risk management skills positively influence the implementation of safety tasks, which in turn, promotes safety climate development. Budgeting skill also positively impacts the development of safety climate. The findings demonstrate the importance of technical skill of project personnel in managing construction safety. The findings also indicate that the implementation of safety tasks is essential for developing safety climate, thus construction companies should consider to include these tasks into their safety management program. It is also suggested that construction companies should incorporate relevant safety aspects into their technical skill development programs, thus project personnel can use their technical skill to improve the levels of safety task implementation and safety climate development.

Keywords: project personnel, risk management, safety climate, safety tasks, technical skill.

INTRODUCTION

The fatality and incidence rates of the construction industry are considerably higher than the industry average (Lingard and Rowlinson 2005). Consequently, it is imperative for the construction industry to improve its safety performance. Besides managing the triple bottom line of time, cost, and quality, project personnel also have an important role in influencing safety performance of a construction project. Mattila *et al.,* (1994) conducted a study at 16 building sites and found that effective supervisory behaviour leads to better safety. Another study by Langford *et al.,* (2000) found that supervisors having positive safety behaviour on site influences workers' attitudes. They also pointed out that better safety performance can also be expected when site managers and supervisors engaging in regular safety talks with workers. Furthermore, it has been indicated that project personnel have an important and ongoing safety leadership role (Dingsdag *et al.,* 2006).

Fulfilling this responsibility requires project personnel to possess adequate skills. One of the most important skills in construction management is technical skill (Sunindijo and Zou, 2011). Much research has been done to investigate the role of human skill,

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such as leadership, behaviour, attitudes, and culture, in managing safety (Glendon *et al.*, 2006; Lingard and Rowlinson, 2005). In contrast, only a few has explored the role of technical (or hard) skill, hence this research aims to fill this gap by considering technical skill as a contributing factor to help project personnel manage safety.

This research began by exploring previous literature to develop a theoretical model that shows how technical skill can influence safety performance in a construction project. This model was then tested using structural equation modelling (SEM) technique and a best-fit model was determined. Relationships between variables in the model are discussed along with the implications and limitations of the research as well as potential future research.

THE THEORETICAL MODEL

Safety management tasks and safety climate are indicators of safety performance used in this research. A safety management task is a definable activity, action, or process that project personnel need to perform to provide safety leadership. Dingsdag *et al.*, (2006) with the input from the Australian construction industry have identified 39 safety management tasks that project personnel, particularly the ones who occupy safety critical positions, need to perform competently and effectively. Sunindijo and Zou (2009) argued that project personnel can contribute to the development of safety climate in a construction project by performing those 39 safety management tasks. Safety climate is "shared employee perceptions of how safety management is being operationalised in the workplace at a particular moment in time" (Cooper and Phillips 2004: 497). Safety climate has been used in many industries to measure safety performance. The popularity of safety climate can be attributed to its advantages: (1) it is a leading indicator that can identify safety problems before they develop into accidents and injuries, (2) it provides a mechanism to optimise investment on safety-related improvements, (3) it serves as a valuable tool to identify safety trends and establish benchmarks, (4) a safety climate survey costs less money and time to be carried out, (5) it involves employees in the process, which helps identify key issues that need to be addressed, and (6) many studies have revealed the importance of safety climate in predicting or measuring safety-related outcomes (Davies *et al.*, 2001; Glendon and Litherland 2001; Seo *et al.*, 2004; Zou and Sunindijo 2010).

Technical skill is one of the essential skills required by project personnel to perform safety management tasks, which will lead to safety climate development. Technical skill is an understanding of job-specific knowledge and techniques that are required to perform specific tasks proficiently. It involves specialised knowledge, analytical ability within that speciality, and facility in the use of tools and techniques of a specific discipline (Katz 1974). Sunindijo and Zou (2011) conducted a literature-review study and summarised that scheduling, budgeting (or cost management), quality management, document management, risk management, and procurement management are essential technical skills in construction management.

Consequently, there are three interrelated aspects in this research, i.e., technical skill, safety management tasks, and safety climate. Technical skill serves as the input or the tool needed by project personnel for managing safety. Safety management tasks are the process or what project personnel should do during the implementation of safety programs. Lastly, the development of safety climate is the outcome or the goal of safety management in a construction project. This is a deduction that forms the theoretical model shown in Figure 1. Two hypotheses can be derived from the theoretical model:

1. Hypothesis 1: the higher the level of technical skill of project personnel, the higher the level of safety management task implementation
2. Hypothesis 2: the higher the level of safety management task implementation, the higher the safety climate.

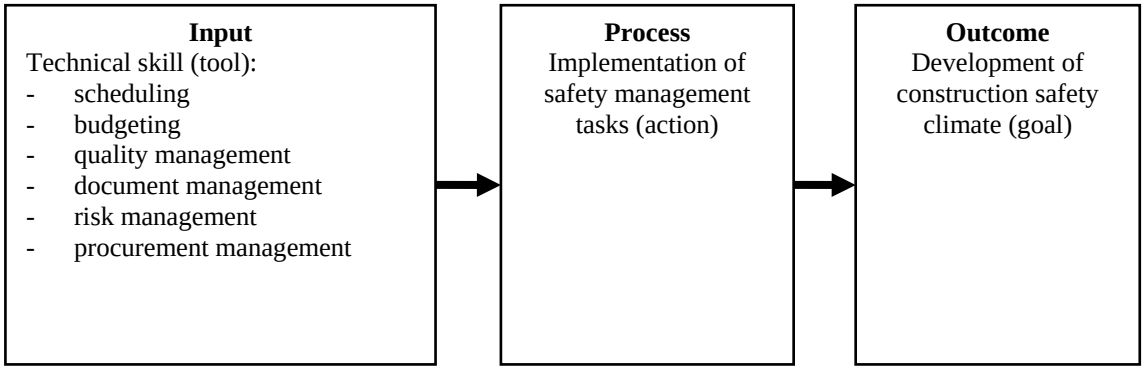

Figure 1 Theoretical model for this research

RESEARCH METHODOLOGY

This research is rooted in positivism epistemology assumption which supports the application of natural science methods to the study of social reality (i.e. construction safety). The best methodology to acquire knowledge rooted in this philosophical standing is quantitative research methodology. Three sets of questionnaires were used to measure the three aspects included in the theoretical model. The first set of questionnaire for measuring technical skill contains 16 items identified from previous literature. It was designed to measure the six aspects of technical skill identified by Sunindijo and Zou (2011). For brevity, each aspect was measured only by using two or three items. The second set of questionnaire measured the level of implementation of safety management tasks. It contains 39 items based on the 39 safety management tasks identified by Dingsdag *et al.*, (2006).

The third set of questionnaire for measuring safety climate was designed based on previous studies (Zohar 1980; Brown and Holmes 1986; Dedobbeleer and Béland 1991; Williamson *et al.*, 1997; Cox and Cheyne 2000; Glendon and Litherland 2001; Mohamed 2002; Zohar and Luria 2005; Lin *et al.*, 2008; Zhou *et al.*, 2009). At first, 157 safety climate items were considered in the development of this questionnaire. Based on frequency analysis, the safety climate questionnaire was finalised consisting of 20 items. All questionnaires were self-assessed and used a 5-point Likert scale format ranging from strongly disagree to strongly agree (technical skill and safety climate) and from poor to good (implementation of safety management tasks).

Pilot study with the involvement of 10 experts in the construction industry has been conducted to ensure that all items in the questionnaires are clear and unambiguous. The questionnaires were distributed through a web-based online survey. Using a convenience sampling approach, three major construction companies (each has more than 300 employees) headquartered in Australia participated in the survey.

DATA ANALYSIS

In total, 356 project personnel have participated in the survey ranging from safety personnel, site supervisors, engineers, project managers, and construction managers. Among those, 273 responses were valid and used for further analysis. The average working experience of the respondents is more than 18 years indicating that they are

experienced personnel in the construction industry, which also strengthens the validity of this research.

Prior to testing the hypotheses, it is necessary to check the reliability of the questionnaires. A questionnaire is considered reliable when it produces the same or similar results regardless of opportunities for variations to occur (Nunnally and Bernstein 1994). The reliability of the questionnaires is evaluated by their Cronbach's alpha values as presented in Table 1. The values for quality management and document management skills are relatively low in which 0.700 or above is normally considered as an acceptable value. However, low Cronbach's alpha values are common in new questionnaires. Furthermore, deletion of these items will not increase the Cronbach's alpha of the overall technical skill. Coupled with the exploratory nature of the research, it was decided to keep all items in the questionnaire.

Table 1 Reliability test results of the questionnaires

Construct	Cronbach's alpha	No of items
Scheduling	0.730	3
Budgeting	0.731	3
Quality management	0.581	2
Document management	0.627	3
Risk management	0.895	3
Procurement management	0.857	2
Overall technical skill	0.867	16
Safety management tasks	0.977	39
Safety climate	0.929	20

Since the aim of the analysis is to test a theoretical model (Figure 1), structural equation modelling (SEM) was selected for this purpose. SEM is a statistical method that takes a hypothesis-testing approach to the analysis of a structural theory bearing on some phenomenon (Byrne 2010). It allows a simultaneous examination of relationships among independent and dependent variables or constructs within a theoretical model (Mohamed 2002). AMOS 18 (analysis of moment structures version 18) was the SEM software package used in this research.

The best-fit model derived from the SEM analysis is presented in Figure 2. The probability value of the chi-square test is higher than 0.05 (P=0.357) which indicates that the model fits the data while also still maintaining the theoretical model. The numbers on the arrows are the unstandardised regression coefficients, which represent the amount of change in the dependent variables per single unit change in the predictor variables (University of Texas 2002). For example, for every single unit of increase in safety management task implementation, the level of safety climate is increased by 0.55. Each technical skill is correlated to each other as indicated by the double-headed arrows. There are four statistically significant relationships in the SEM model. Document management and risk management skills are the predictors of the level of implementation of safety management tasks. In addition, the level of implementation of safety management tasks and budgeting skill work in tandem to promote the development of safety climate.

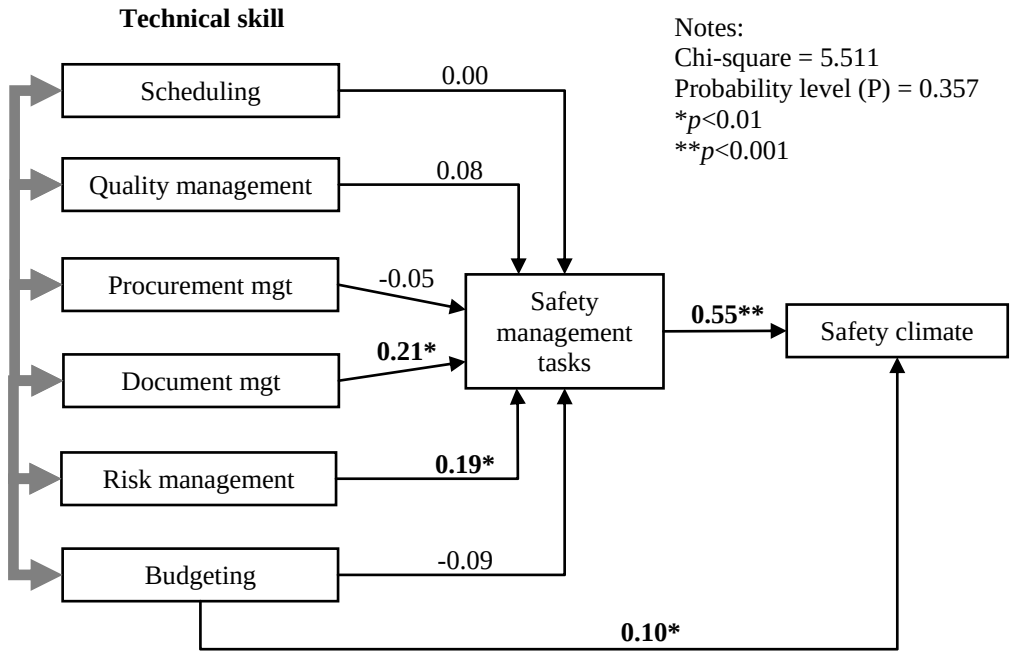

Figure 2 The best-fit model derived from SEM analysis

DISCUSSION

In general, the SEM model supports Hypotheses 1 and 2, although only two aspects of technical skill (i.e. document management and risk management) strongly influence the level of implementation of safety management tasks. Additionally, there is a direct relationship between budgeting skill and safety climate. The meanings and implications of the relationships are discussed in the following subsections.

Document management skill and safety management tasks

Document management skill refers to the ability to use an effective documentation system and procedure for performing daily activities and tracking various changes that might happen in a construction project. It also involves a proficiency in managing various project documents, such as drawings, submittals, requests for information, safe work method statements, change orders, and payment requests. Document management may seem trivial for some people, but poor performance on this area could be devastating. For example, inaccurate payment requests or late responses to requests for information will disrupt the entire construction process. The work flow will suffer, which will affect the schedule and budget, thus putting the entire project at risk. Document management may have nothing to do with the actual works on site, but it has an important role for the overall project success (Jackson 2004).

The case is the same when it is applied to the implementation of safety management tasks. Document management skill is required to implement many safety management tasks successfully. For example, the task of developing safety procedures and instructions require a capacity to create and develop process documents that comply legislatively and meet the company's values. Furthermore, these procedures and instructions must be available in a written format and distributed to relevant stakeholders for maintaining safety standards in the project (Dingsdag *et al.*, 2006). Jaselskis *et al.*, (1996) suggested that providing more detail to a written safety program can reduce the incidence rate of a construction company. Langford *et al.*, (2000) found that providing every worker with a safety booklet or manual is important

for developing positive attitudes towards safety. This implies that document management skill is needed to prepare such written safety program and to distribute the program to everyone involved.

Among the 39 safety management tasks, at least 21 of them require the application of document management skill in their implementation. Further correlation analysis shows that 23 safety management tasks are significantly correlated at the 0.01 level with document management skill demonstrating its importance for implementing safety management tasks.

Risk management skill and safety management tasks

The construction industry is widely associated with a high degree of risk due to the nature of construction business activities, processes, environment, and organisation. Risk is always the object of attention in construction projects because of its impact on the achievement of project objectives (Akintoye and MacLeod 1997). Understanding of risk management is a core of safety management tasks. The first 21 safety management tasks are classified into two categories. The first category is proactively identify, assess and determine appropriate controls for safety risks and the second one is effectively communicate and consult with stakeholders regarding safety risks (Dingsdag *et al.,* 2006).

By simply examining these two categories, the importance of risk management skill is clear. The first category is basically to perform the whole process of risk management. This category is mainly a proactive approach where safety risks are identified and managed in advance before the project begins. Risk identification is a crucial process because unidentified risks negate the whole risk management process. Risks cannot be assessed and mitigation strategies cannot be developed and implemented if those involved are not aware of the risk in the first place (Carter and Smith 2006).

The second category is more process oriented in which the tasks are mainly performed during the construction stage. Understanding of risk management is crucial in this second category because it involves communicating safety risks to relevant stakeholders to ensure that each activity in the project is performed according to safety procedures and risk mitigation strategies. Risk management, therefore, is a continuous process throughout construction life cycle (Akintoye and and MacLeod 1997). In addition, other categories of safety management tasks are somewhat related to risk management as well. Correlation analysis shows that 19 safety management tasks are significantly correlated with risk management skill at the 0.01 level, while another 13 tasks are correlated at the 0.05 level. This provides empirical evidence on the influence of risk management skill on the implementation of safety management tasks.

Budgeting skill and safety climate

This relationship was not anticipated at first. However, further scrutiny proved the logic behind the relationship. Table 2 shows some significant correlations (at 0.01) between budgeting skill and safety climate items. Estimating costs of project activities are correlated to sufficient training and company's safety policy and procedures. Sufficient budget is necessary to conduct training for project personnel before they start working on the project. Furthermore, this estimation should also consider the budget needed to implement company's safety management system which makes safety policy, procedures, and information available to everyone involved. Jaselskis *et al.,* (1996) suggested that proper safety budget allocations in terms of increasing the amount of money expended on safety awards has a positive impact on reducing the

incidence rate of a construction project. On the contrary, productivity bonuses lead to risk taking behaviour due to the motivation to speed up the pace of construction, thus this kind of productivity bonus system must be carefully thought as not to be detrimental to safety performance (Langford *et al.,* 2000).

Table 2 Correlations between budgeting and safety climate items

Budgeting	Corre-lation	Safety climate	
		Sufficient training to perform job safely	The availability of company's safety policy and procedures to everyone
Estimating costs of project activities	Pearson Sig.	0.171* 0.005	0.187* 0.002

** significant at 0.01*

It is also essential to examine the relationship between budgeting skill and safety climate from a bigger perspective. A case study by Zou *et al.,* (2010) found that safety investment has generated a return on investment of about 46%. On the contrary, lack of safety has an adverse impact on the economic performance of a construction project because an accident can cost up to A$1.6 million (Sun and Zou 2010). Without proper understanding of cost-benefit analysis, project personnel may not appreciate the potential savings from implementing necessary safety measures, thus this explains the relationship between budgeting skill and safety climate. Furthermore, safety climate is about people's perceptions on safety. Budgeting is essentially about allocating monetary resource to each construction activity. In this context, when proper budget allocation for safety measures is included in every activity package, then this will influence people's perception concerning the safety commitment demonstrated by the management of the company. Consequently, the level of safety climate in the project will improve.

Safety management tasks and safety climate

The implementation of safety management tasks influences the development of safety climate in a construction project. This relationship is straightforward and has been anticipated as stated in Hypothesis 2. The result of correlation analysis shows that each safety management tasks (39 in total) is significantly correlated (at 0.01 level) to overall safety climate. This provides strong empirical evidence demonstrating the importance of implementing safety management tasks for developing safety climate. Based on this finding, it can be argued that when project personnel perform the required safety management tasks, they provide safety leadership in their projects, thus they will positively influence the attitudes and perceptions of others towards safety. As mentioned before, these attitudes and perceptions shape the safety climate in a construction project which is an important indicator of safety performance.

Limitations and future research

Three potential limitations of this research deserve attention. Firstly, the data were self-assessed, thus a common-method bias may occur. For instance, different respondents may have different interpretations concerning what is the standard of good safety climate or high level of safety management tasks. In spite of this limitation, this research offers support and empirical evidence for the proposed research model which can be a useful foundation for future research.

Secondly, the items to measure quality management and document management skills have low Cronbach's alpha values. This may indicate that the questionnaire items are not reliable for these two skills. However, deleting these items does not increase the

Cronbach's alpha of the overall technical skill questionnaire, which indicates that they actually do not have negative effect on the reliability of the overall technical skill questionnaire. Future research may want to build on this questionnaire for measuring the technical skill of project personnel.

Thirdly, three major construction companies headquartered in Australia participated in the data collection process. These three companies may not represent the whole construction industry. Future research should collect data from medium- and small-sized construction companies to investigate whether there are differences in the results. This limitation, however, should not nullify the empirical evidence found in this research demonstrating the role of technical skill in influencing the level of implementation of safety management tasks and safety climate.

CONCLUSIONS

The findings suggest that technical skill, particularly document management, risk management, and budgeting skills, can influence the implementation of safety management tasks and the development of safety climate in a construction project. An effective document management system should be established for receiving, restoring, retrieving, and disseminating safety information and documents in a timely manner. More importantly, project personnel should have the skill to operate the system in performing their works.

Risk management has become part of the construction industry because of its high-risk nature. Risk management is also a core in the implementation of safety management tasks, thus it is essential for project personnel to have sufficient risk management skill to perform and manage those tasks. This skill is manifested in the ability to identify, analyse, evaluate, and treat risks throughout the construction life cycle. Construction companies should provide training and conducive learning environment for their project personnel to develop this skill.

Budgeting skill directly influences the development of safety climate. Project personnel should be able to estimate the costs required to implement safety measures in their project. Proper understanding of cost benefit analysis also helps project personnel appreciate the potential benefits of implementing safety measures and the losses that may incur due to an accident. The implementation of productivity bonus system must be thought carefully because it may have adverse impact on safety performance. Lastly, by showing commitment to invest in safety measures, construction companies can contribute to the development of safety climate.

The construction industry should recognise the value of technical skill in its efforts to improve safety performance. Construction companies should consider incorporating relevant safety aspects into their technical skill development programs. In addition, this research confirms that the implementation of safety management tasks is crucial for developing safety climate. Therefore, construction companies should consider implementing and integrating these tasks into their existing safety programs.

This research offers contribution to the body of knowledge by pointing out the importance of technical skill in safety management. The exploratory nature of the research opens windows of opportunities for future research to explore further on this topic. Each component of technical skill can be investigated in depth to find out how it can contribute to improve safety performance. It is also important for future research to recommend how each aspect can be developed and integrated into existing safety and human resource training programs.

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