4TH Triennial International Conference
Rethinking and Revitalizing Construction
Safety, Health, Environment and Quality
Port Elizabeth – South Africa
17-20 May 2005
ISBN 0-620-33919-5
pp. 282-292

CIB034

Organizational Safety Culture: A System Dynamics Approach

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1. ABSTRACT

There has been an increasing recognition of the importance of organizational and behavioral aspects of safety management in construction. Collectively, those aspects give rise to the 'safety culture' term, which recently became a subject of considerable conceptual and research interest. This paper describes the early stages of a research project that uses a system dynamic approach in an innovative way to improve our understanding of the emergent nature of organizational safety culture. Particular emphasis is given to the causal relationships among the different organizational and behavioral variables identified in the literature as enablers, and the expected results of having a mature and positive organizational safety culture.

2. INTRODUCTION

2.1 Safety Culture

The development of an effective safety culture has been recognized as a vital element in the achievement of high standards of safety, alongside an effective safety management system and organizational structure (Wright et al., 1999). The term safety culture was first introduced by the International Atomic Energy Agency as a result of their analysis into the nuclear reactor accident at Chernobyl in 1986 (Gadd and Collins, 2002). The identification of poor safety culture as a factor contributing to this accident led to a large number of studies investigating and attempting to measure safety culture in a variety of different high-hazard industries (Little, 2002). No single definition of what constitutes a safety culture exists. However, the majority does appear to have the commonality that it includes the norms, rules and behaviors that are presented with respect to safety, as well as the characters of the organization, the beliefs and values that are exhibited (Potter, 2003). One of the most widely used safety culture definition is that developed by the Advisory Committee on the Safety of Nuclear Installation. This definition is based on a study group on human factors (HSE, 1993), and describes safety culture as "the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management.

Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures." This broad-based definition is adopted in this paper. Other definitions, however, are listed in Table 1.

2.2 Measuring Safety Culture

According to Hinze (1997), written safety plans can be effective but organizations must go beyond the letter of the plan and create a true safety culture. This fact highlights the need not only to better understand the role played by the organizational and behavioral variables identified in the above listed definitions, but also to measure their individual contributions in creating and nurturing a true organizational safety culture. Over the past few years, attempts have been made to measure and benchmark such contributions, and to present their 'aggregate' score as an indicator of the 'health' of organizational safety culture in construction. A brief summary of the main features of three reported attempts is given below.

Table 1: Definitions of safety culture

Definition	Source
"That observable degree of effort by which all organizational members direct their attention/actions toward improving safety on a daily basis."	Cooper, 1993
"Those aspects of the organizational culture which will impact on attitudes and behavior related to increasing or decreasing risk."	Guldenmund, 2000
"The attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems."	Hale, 2000
"An environmental setting where everyone feels responsible for safety and pursues it on a daily basis, going beyond `the call of duty' to identify unsafe conditions and behaviors, and intervene to correct them... people 'actively care' on a continuous basis for safety... (which) is not a priority that can be shifted depending on situational demands, rather safety is a value linked with all other situational priorities."	Geller, 2001
"Safety culture is viewed as involving perceptions and attitudes as well as the behavior of individuals within an organization."	Harvey *et al.*, 2002
"The ideas and beliefs that all members of the organization share about risk, accidents and ill health."	The Confederation of British Industry (in Cooper, 2002)

(Source: Potter (2003))

Wright *et al.* (1999) developed a Safety Culture Improvement Matrix (SCIM) based on an internationally recognized business model (The EFQM Excellence

Model). The SCIM, which is a self-assessment tool, could be 'scored' in two methods. The first method simply entails a judgment of whether each and every element of the SCIM's nine elements (e.g. leadership, policy, resources, etc.) has been satisfied. This is achieved by asking the organization to what extent the particular element has been satisfied. Elements that are wholly satisfied can be colored green, partly satisfied yellow and unsatisfied elements red. The second method entails scoring individual questions (from 0 to 100 based on the judgment of the assessors) and calculating both element specific and overall scores. Once a weighed score for each element is obtained, it is added together to achieve the total or overall organizational safety culture score.

Molenaar *et al.* (2002) identified a total of 31 characteristics that define organizational safety culture. The characteristics were then organized into a hierarchical structure and broken down into 54 measurable questions in a questionnaire survey to operationally measure these characteristics. All questions were based on previously proven research. The survey results served in a type of 'snap-shot' assessment of organizational safety culture.

Mohamed (2003) adopted the Balanced Scorecard tool to benchmark organizational safety culture. He argued that this tool has the potential to provide a medium to translate safety plans and processes into a clear set of goals, which are, in turn, translated into a system of performance measures. The tool offers the advantage of providing a mix of objective and subjective performance measures that could effectively communicate a powerful strategic focus on safety to the entire organization, and is also conducive to organizational learning by providing feedback on targets of performance measures that have not been achieved.

The above attempts demonstrate the value realized in measuring safety culture and in identifying areas for improvement. Measurement of organizational safety culture is not a trivial task, and by focusing only on the contributions made by individual variables (organizational or behavioral), the interactions between these variables as well as the likely consequences of safety initiatives being undertaken over time get ignored. Moreover, the above attempts say very little about the causal links between what the organization is, or should be, doing and what it aims to achieve. To demonstrate, a safety management system which is a complex interactive set of organizational variables (enablers) may not function according to what has been originally planned and predicted (results). This is due to a number of reasons including the difference in perceptions of safety culture which has the potential to determine how successful the process of system implementation is.

There has also been little examination of the extent to which there is a consensus among workers and managers regarding the contributions of the identified enablers in determining perceptions of safety culture. Based on the SPICE process improvement framework for construction (Sarshar *et al.*, 2000), it is not difficult to argue that implementing safety initiatives that are not addressing priority areas for improvement may add little value to the organization in its quest to improve its

safety culture. In other words, organizations should realistically assess the maturity level of their safety culture and progress sequentially through the different levels of culture maturity – one of the aims of the project reported herein.

Safety improvement requires continuous flow of information about hazards, processes, incidents, etc. Information from workers, supervisors and other stakeholders are also critical for improving safety. With this in mind, it is clear that there is a need for a means to explore and investigate the interaction between different enablers and to predict the implication of each and every enabler over a period of time. Building upon the earlier work by Wright *et al.* (1999), this paper describes the early stages of a PhD research project which aims to develop such a means via system dynamics (SD) modelling. It is envisaged that the developed tool will provide a systematic process to help understanding key organizational and behavioral aspects of safety culture, their effect and interaction, thus adding value to the organization's strategic safety plans. The tool should also help organizations to prioritize areas for improvement and plan how to make improvements. The project uses a SD approach to highlight the causal relationships among the different organizational and behavioral variables identified in the literature as 'enablers' for, and 'results' of, having a positive organizational safety culture. The foremost step in system modelling is to understand the situation to be modelled and its interactions, both internal and external. This would mean the identification of the enablers and results that influence the occurrence of the situation. The following section provides a brief description of the enablers and predicted results as identified by the European Foundation for Quality Management (EFQM) Excellence Model – modified slightly to suit safety management and to build on the work reported by Wright *et al*. (1999).

3. THE EFQM EXCELLENCE MODEL

EFQM is a membership based not-for-profit organization, created in 1988 by 14 leading European businesses. It has a key role to play in enhancing the effectiveness and efficiency of European organizations by reinforcing the importance of quality in all aspects of their activities and stimulating and assisting the development of quality improvement as a basis for their achievement of organizational excellence (www.efqm.org). The EFQM Excellence Model proved to be effective for organizations to implement in order to improve the quality of their processes, and has been used in business in general and specific industries, such as hospitality, education and construction (Camison, 1996). 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 model recognizes there are many approaches to achieving sustainable excellence in all aspects of performance. It is based on the premise that *"Excellent results with respect to Performance, Customers, People and Society are achieved through Leadership driving Policy and Strategy, that is delivered through People, Partnerships and Resources and Processes"* (www.efqm.org).

The EFQM Excellence Model consists of nine criteria, five of which are 'enablers' and four of which are 'results'. Put simply, enablers cover what an organization does, while results cover what an organization has achieved. The model is presented graphically in Figure 1.

Criterion weights are an important part of the model. The model divides 1000 points between the nine criteria, typically allocating 60/40 split between enablers and results. In this research, these nine criteria of safety culture will be used as a viable framework for developing a safety culture index through SD modelling to: 1) assess the current maturity level of safety culture in the organization, 2) investigate the interaction between the different criteria and 3) provide continuous improvement via *modifying the system to achieve better results. The definitions of the nine criteria are as follows.*

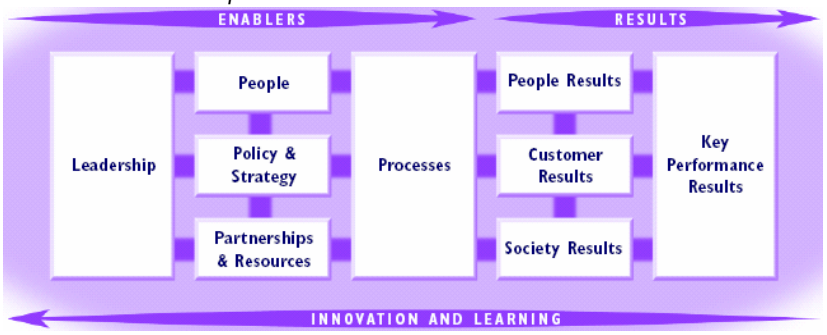

Figure 1: The EFQM Excellence Model (www.efqm.org)

3.1 Leadership

How leaders develop and facilitate the achievement of the mission and vision of safety, develop values required for long-term success and implement them via appropriate actions and behaviors, and are personally involved in ensuring that the organization's safety management system is developed and implemented. There are a number of aspects of leadership including:

- Visible management commitment (Mohamed, 2002)
- Trust between management and employees (Lardner *et al.*, 2001)
- Management accountability (Little, 2002)

3.2 Policy and Strategy

How the organization implements its mission and vision of safety via clear stakeholder focused strategies, supported by relevant policies, plans, objectives, targets and processes. There are a number of aspects of this enabler including:

- Safety awareness and promotion; e.g. rewards, recognition (Lingard and Rowlinson, 1994)
- Alignment of productivity and safety targets (Niskanen, 1994)
- Safety standards (Glendon and Litherland, 2001)

- The impact of regulatory bodies (Tam *et al.*, 2004)

3.3 People

How the organization manages, develops and releases the knowledge and full potential of its people at an individual, team-based and organization-wide level, and plans these activities in order to support its policies and strategies and the effective operation of its processes. There are a number of aspects of this enabler including:

- Safety empowerment and responsibilities (Glendon and Litherland, 2001)
- Shared perceptions about safety (Siu *et al*., 2004)
- Proactive participation in safety (Mohamed, 2002)
- Positive attitude towards workplace (Niskanen, 1994)
- Supportive environment and teamwork (Lingard and Rowlinson, 1994)
- Distress or emotions e.g. anxiety, frustration (Siu *et al*., 2004)

3.4 Partnerships and Resources

How the organization plans and manages its external partnerships with project participants and other stakeholders, and internal resources in order to support its safety policies and strategies and the effective operation of its safety-related processes. Partnerships and resources consist of the following elements:

- Project participants and stakeholders cooperation (Little, 2002)
- Necessary safety resources (Mattila *et al*., 1994)
- Financial resources (Tam *et al*., 2004)

3.5 Processes

How the organization designs, manages and improves its processes in order to support its policy and strategies and fully satisfy, and generate increasing value for, its customers, employees and other stakeholders. This enabler consists of the following elements:

- Safety related activities; e.g. safety training, safety auditing (Glendon and Litherland, 2001)
- Risk and hazard assessment (Little, 2002)
- Organizational learning (Lardner *et al.*, 2001)
- Site layout planning, environment control and good housekeeping (Glendon and Litherland, 2001)
- Monitoring and feedback (Glendon and Litherland, 2001)
- Site safety documentation e.g. documented risk plans, site safety plans, site accident logbook, minutes of site safety meetings (Tam *et al*., 2004)
- Incident reports and accident analysis (Speirs and Johnson, 2002)

3.6 People Results

What the organization is achieving in relation to its own employees. This enabler consists of the following elements:

- Level of job satisfaction (Siu *et al.*, 2004)
- Safe work behavior (Dejoy *et al*., 2004)

- Workforce morale (Mohamed, 2003)

3.7 Customer Results

In the context of safety, what the organization is achieving in relation to its external customers (e.g. clients and project participants) and other stakeholders. This enabler consists of the following elements:

- Fewer complaints (Mohamed, 2003)
- Exceed customers' expectations (Mohamed, 2003)

3.8 Society Results

In the context of safety, what the organization is achieving in relation to the local community and the society as appropriate. This enabler consists of the following elements:

- Risk and hazard reduction for all involved and affected (Little, 2002)
- Improved industry image and safety standards (Tang *et al*., 2003)
- Reduced social costs of accidents usually borne by the society and its institutions (Tang *et al.*, 2003)

3.9 Key Performance Results

What the organization is achieving in relation to its planned performance. This enabler consists of the following elements:

- Enhancement of safety practices (Siu *et al*., 2004)
- Reduced number of accidents and safety related incidents (Dejoy *et al.*, 2004)
- Reduced financial costs of accidents usually borne by the organization (Mohamed, 2003)
- Performance reliability and hence higher productivity (Mohamed, 2003

4. SYSTEM DYNAMICS

System dynamics is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems. A system is characterized as a composite of inputs which when processed, delivers outputs. However, feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. One cannot study the link between X and Y and, independently, the link between Y and X and predict how the system will behave. Only the study of the whole system as a feedback system will lead to correct results (System Dynamics Society, 2004). In fact, it has been used to address practically a number of real-world feedback systems in construction (Chritamara and Ogunlana, 2002, Tang and Ogunlana, 2003). The SD methodology includes (System Dynamics Society, 2004):

- Identifying a problem;
- Developing a dynamic hypothesis explaining the cause of the problem;
- Building a simulation model of the system at the root of the problem;
- Testing the model to be certain that it reproduces the behavior seen in the real world;
- Devising and testing alternative policies that alleviate the problem; and

- Implementing this solution.

As mentioned earlier, the safety culture model would consist of five enablers to achieve four desired results. The basic safety culture model is shown below, where a safety culture index represents the sum of enablers and results briefly defined in section 3. This reflects the assumption that the safety culture index could be 'healthier' provided that the organization focuses on improving the enablers and achieving more desired results. This also means that the model is at a strategic level, thus details of operational activities are not included.

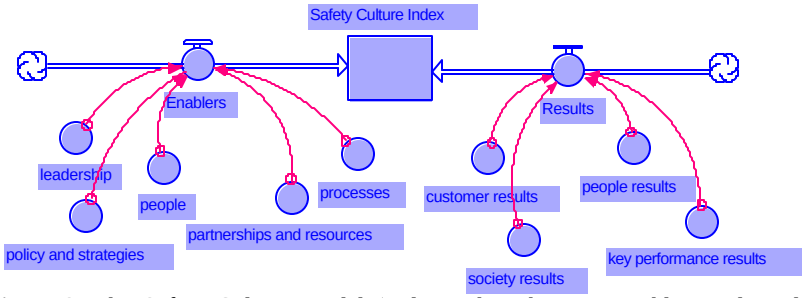

Figure 2: The Safety Culture Model (Relationships between enablers and results are omitted for clarity)

The SD model aims to capture major feedback processes responsible for the system behavior with a strong focus on the identified enablers believed to have a dominant effect on safety culture. The SD model could be represented by a number of causal loop diagrams. A causal loop diagram is a SD tool which helps the modeller to conceptualize the real world system in terms of feedback loops (Khanna *et al.*, 2002). In a causal loop diagram, the arrows indicate the direction of influence, and the plus/minus signs the type of influence. Generally speaking, if a change in one criterion generates a change in the same direction in the second criterion, the relationship between the two criteria is referred to as positive. If the change in the second criterion takes place in the opposite direction, the relationship is negative. Using the above-identified nine criteria (i.e. five enablers and four results) in the model, one could represent the relationships (already discussed in the literature) between them. For illustration purposes, an example of a basic safety culture causal loop diagram linking a limited number of enablers together is diagrammatically shown below. Figure 3 shows that increased management commitment towards safety (Leadership) will tend to increase the number and intensity of safety related activities (Processes), which in turn will significantly enhance perception of safety (People) (Arboleda *et al.*, 2003), and be reflected as an improvement in the safety culture index (Gillen *et al.*, 2002).

Figure 3: Safety culture causal loop diagrams

Notable increased perception of safety has the potential to increase the level of participation in safety activities (People) (Dedobbeleer and Beland, 1991). Thus, more safety resources (Partnerships and resources) are required which is the result of more people participating in safety activities (Pipitsupaphol and Watanabe, 2000). This will unfortunately tend to put more pressure on management commitment towards safety (Speirs and Johnson, 2002). Negatively affecting management commitment towards safety closes the loop. Thus, the feedback loop between management commitment towards safety, safety activities, perception of safety, participation in activities, and resources is a negative loop.

Continuing with our example, a higher level of participation in safety activities will tend to decrease the distress (People), leading to a reduced accident rate (Key performance results) (Siu *et al.*, 2004). A reduced accident rate would lead to higher job satisfaction (People results) (Siu *et al.*, 2004), which in turn will enhance the people's perception of safety (Gillen *et al.*, 2002). Thus the feedback loop between perception of safety, participation in activities, distress, accident rate and job satisfaction is a positive one. Undoubtedly, the higher the level of job satisfaction, the more positive the safety culture index (Siu *et al.*, 2004).

5. WORK IN PROGRESS

At present, work is underway to develop a comprehensive dynamic simulation model of safety management in construction from the perspective of strategic management decisions. The second objective for developing the model is to analyze the impact of various safety-related enablers discussed in the literature on safety, and to test their effectiveess in improving organizational safety culture. The model is being built using the SD methodology and STELLA software (www.iseesystems.com). Model input (relationships and weightings) will be derived from the literature, and collected from industry via questionnaire surveys.

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