Self-assessment analysis tool for benchmarking safety culture

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ABSTRACT: The relationship between a mature safety culture and accident frequency has been recognized in a variety of industrial settings, including the construction industry. This paper is inspired by the advanced research studies conducted to identify critical factors of total quality management (TQM). The paper employs a descriptive research approach in identifying the critical factors that are absolutely essential to develop and nurture a mature organisational safety culture. It develops and presents a self-assessment analysis tool for benchmarking safety culture, in the context of the construction industry. To demonstrate the tool's effectiveness, the paper performs a benchmarking exercise utilising input solicited from large- and medium-sized contracting organisations operating in Hong Kong. The information gathered through this exercise highlights performance gaps in levels of implementation of identified critical safety culture factors. Such gaps should be used as the basis to prioritise areas for improvement in order to create a safer working environment.

1 INTRODUCTION

Although there is no single definition of what constitutes safety culture, the relationship between a mature safety culture and accident frequency has been recognized in a variety of industrial settings, including the construction industry. Construction safety literature has identified a mature safety culture as one characterized by continual improvement – a culture that contains policies, objectives, targets, procedures, records and audits, but sees these as tools to aid the performance of empowered teams.

Over the past few years, a number of attempts have been made to measure and benchmark the contributions made by individual organisational factors, 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.

Wright et al. (1999) developed a Safety Culture Improvement Matrix (SCIM) based on an internationally recognized business model (The EFQM Excellence Model). 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 'snapshot' 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. However, they adopt a normative approach which relies on questionnaire surveys that elicit respondents' opinions of "what ought to be" or "what should be" implemented. Thiagarajan & Zairi (1998) criticize this approach and call for adopting a descriptive approach when studying ideal or desired management practices. In the descriptive approach, respondents first indicate the factors perceived to be critical to achieving a mature safety culture, and then they rate their level of criticality. Thus, facilitating objective judgment to be used in identifying consensus on the level of perceived importance of these factors. This paper adopts the descriptive approach which has been successfully applied in TQM by Baidoun (2003) and Thiagarajan & Zairi (1998), but in the context of safety culture.

2 SAFETY CULTURE

Over the past few years, various safety management systems have been introduced, aiming at effectively monitoring the safety policies, procedures, and practices within construction companies, however, safety practices encountered in construction sites are as varied as the sites themselves (Wilson & Koehn 2000). A number of these systems and their associated measures have been reviewed and criticised for their pre-occupation with the negative consequences of site accidents rather than proactive prevention strategies (Mohamed 2003). Calls were made for creating and maintaining a true 'safety culture' in construction – a culture, which is based on the premise that safety is the priority (i.e. the way of life).

Numerous definitions of safety culture abound in the literature, with all of them identifying it as being fundamental to an organization's ability to manage safety-related aspects of its operations (Glendon & Stanton 2000). Measuring safety culture, however, is a complex task due to the numerous beliefs, values, and behaviors that create an organization's safety culture. Safety culture relates to the determinants of the ability to manage safety, which, in turn, reflect the effectiveness and efficiency of the safety managerial and operational procedures.

3 QUESTIONNAIRE AND SAMPLE

The main aims of this paper are to identify the critical factors needed for creating and nurturing a mature safety culture, and to develop a self-assessment analysis tool for benchmarking safety culture.

To achieve these two aims, data were collected through a self-administered questionnaire survey targeting large- and medium-sized contracting organisations operating in Hong Kong. Hong Kong has, until very recently, been a rapidly expanding commercial and financial centre. Local construction activities have brought a parallel increase in injuries to workers (Rowlinson et al. 2003). Reasons for this are discussed elsewhere (Rowlinson 2000).

As the local construction industry moves toward self-regulation and performance-based legislation, all contractors need to implement a well-defined safety management system. Written safety management systems and plans can be effective but organisations must go beyond the letter of the plan and create a true safety culture (Hinze 1997). 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 developed questionnaire comprised a total of 30 safety culture factors gathered through reviewing the extant literature on safety culture in construction.

Analysis and interpretation of the responses to the questionnaire would then allow objective judgment to be used in identifying consensus on the level of perceived importance of the safety culture factors, a requisite to developing a hierarchical critical quality factor structure (Thiagarajan & Zairi 1998). The questionnaire was designed primarily to allow objective identification of consensus amongst the organisations concerned.

The decision concerning the survey sample was made to target the best performing contracting organisations. As such, the sample was not random, but drawn from the best performing contractors, in terms of safety, on the Hong Kong government list. As recommended by Ramirez & Loney (1993), only one questionnaire was sent per organisation. This is to avoid receiving multiple responses from the same organisation. A cover letter explaining the purpose of the study was sent to a potential sample target comprising 38 organisations. This was followed by telephone enquiries to all respondents after a week. From this sample, 32 completed questionnaires were returned. Although, this represents a relatively small population, it was a reasonably good response rate being in excess of what is normally expected of unsolicited survey (circa 25%) and providing adequate data for data analysis. Respondents were either construction or project managers with 3-19 years of experience and safety management responsibilities.

As mentioned previously, the definition of safety culture is complex when all the behavioural and organisational variables are considered. In this study, safety culture is defined as the attitudes, beliefs and perceptions shared by groups within an organisation as defining norms and values, which determine how they act and react in relation to risks and risk control systems (Hale 2000).

A three-point ordinal measurement scale solicited respondents to explicitly identify a safety culture factor as critical or not, thus permitting objective judgment to be made. They were asked to rate each of the 30 factors as to their level of importance to the implementation of a mature safety culture within their organisations, using the following criteria:

- Critical: Factors that they feel are critical and absolutely essential. The organisation will not have a mature safety culture status if these factors are not part of the safety management process.
- Important: Factors that they feel are important but not absolutely essential to achieving a mature safety culture. In other words, the safety management process will survive if these are not addressed, but the organisation will not achieve a mature safety culture until these factors are eventually addressed.
- Somewhat Important: Factors that they feel are of minor importance. These factors will not seriously affect the success or failure of achieving a mature safety culture status.

4 DATA ANALYSIS

Although the three (3) categories (critical, important, and somewhat important) are ordered, they are non-numeric; i.e. there is no indication of distance between them. Integer scoring to assign numbers to each category (1, 2 and 3, respectively) is used.

Weisberg (1992) suggests organising the data into frequency distribution to allow examination and description on the patterns of the responses to be made which can be exhibited effectively in a tabular or graphic form. For this level of investigation, frequency distribution is most appropriate for data handling as it allows responses distribution for a factor to be summarized by computing the typical value (i.e. point of central tendency) and it can be seen how typical this value is (measure of spread) (Weisberg 1992). This is exactly what is needed to achieve the objective identification of consensus and quantitative comparison of the criticality of safety culture factors. According to the three-point scale used, there are only three possible range values. A zero value of the range occurs when all respondents give a factor the same rating (i.e. 1, 2 or 3) where the maximum rating and the minimum rating will be the same. A zero value will mean no spread on the factor, which indicates a tendency for all the responses to cluster into any one of the three categories (Baidoun 2003). To illustrate, a value of one will indicate that the tendency of responses is dispersed around two consecutive categories, whereas a value of two will indicate a tendency for the responses to be dispersed around all three categories or two extreme end categories. In the instances of a value of one or a value of two of the range, the range by itself tells very little about the general agreement of the importance of the safety culture factor. Moreover, this makes the task of building a hierarchy of safety culture factors more difficult.

The above highlights the importance of looking at other measures of spread such as the variation ratio (VR). VR is the proportion of responses that do not fall into the modal category. Put simply, it is a measure of how descriptive the modal category is of the data (Weisberg 1992). Also, it is an appropriate measure of spread for our ordinal data. Thus, VR could be equated to the extent of consensus in opinions to show how critical, a critical factor is (Thiagarajan & Zairi 1998). VR is calculated by subtracting the frequency distribution of the mode, for a factor, from 1. A VR of zero for a critical factor is obtained when all respondents perceive this factor to be absolutely essential to achieving a mature safety culture. Thus, a zero value would mean unanimity (all respondents rated the factor as critical, important or somewhat important), whereas, values of 0.5 or less mean majority consensus. Values greater than 0.5 indicate no majority consensus in rating a certain factor as critical, important or somewhat important.

It should be noted that although the VR is simple to compute, it does not take into account the full distribution of responses. The measure of nominal spread that does take the full distribution of cases into account is the Index of Diversity (ID) which is a dispersion measure based on the proportion of cases in each category (Weisberg 1992). It squares each of those proportions, sums the squares, and subtracts the sum of squares from 1. The index shows the degree of concentration of responses in a few large categories as squaring proportions emphasises the large proportion, much more than the small ones (Weisberg 1992). Therefore, it could be argued that this index is a surrogate measure of agreement amongst respondents concerning the response distribution of each of the safety culture factors.

A low ID value means general agreement on the importance or criticality of a certain factor, whereas, high ID value means general disagreement on the importance of the factor. This means an ID value close to zero will imply near unanimity. A value close to 0.5 represents equal clustering (concentration) around two large categories. Finally, a near uniform distribution in the three categories will give a maximum value close to 0.667, which in this case will mean a high level of disagreement.

5 ANALYSIS OF RESPONSES

5.1 *Range analysis*

All factors' response distributions are unimodal where the most frequently occurring responses appear on one category. A total of 27 factors were stacked on critical and important categories, while the majority of respondents rated only three factors as somewhat important. These factors were consequently eliminated from further analysis. Only three distributions exhibited a zero range value (all respondents rated these three factors as critical).

A total of nine distributions exhibited a range of one, whereas, the rest of distributions exhibited a range value of two. The reader is reminded that distributions with a range of value of zero, one and two can be dispersed into one, two and three categories, respectively as demonstrated in Table 1.

Closer examination of the nine distributions in the range value of one, reveals only six distributions were returned as critical. Given that these six factors do not have a zero range value, a new 'critical' category was specifically introduced. The other three factors were categorised as important. The remaining 18 factors have a range value of two, implying that some respondents returned these factors as of somewhat importance. From these 18 factors, the majority consensus returned nine factors as critical. Accordingly, the categories were further refined as shown in Table 2. Table 3 lists factors description.

Table 1. Categories of safety culture factors by range value.

Range value	No. of Factors	Safety culture factors	Category*
0	3	1,5,11	C
1	9	2,3,9,16-18,20,25,27	C, I
2	18	4,6-8,10,12-15,19,21-24,26,28-30	C, I & SI

*C: critical, I: important, SI: somewhat important.

Table 2. Refined categories of safety culture factors.

No. of Factors	Safety culture factors	Category*
3	1,5,11	AC
6	2,3,9,16,18,27	C
18	4,6,7,10,12,14,15,17,19-26,28,30	I

*AC: absolutely critical, C: critical, I: important.

Table 3. Safety culture factors.

Factor	Brief Description
1	Safety is considered as important as productivity
2	Clear identification of accountability
3	Empowerment and motivation to work safely
4	Shared perceptions of safety
5	Management commitment 'leading by example'
6	Supervisors/foremen assume proactive role in safety
7	Facilitation of team working on safety issues
9	Evaluation and selection of subcontractors
10	Including safety in business development goal setting
11	Encouraging proactive participation in safety
12	Facilitating higher level of job satisfaction
14	Safe behaviour is recognised and rewarded
15	Documented site safety plans in place
16	Feedback and bottom-up communication
17	Adopting zero tolerance as the safety culture standard
18	Periodic safety auditing
19	Formal investigation and analysis of incidents
20	Management of subcontractors
21	Identifying and providing training opportunities
22	Proactive on-site hazard assessment
23	Effective top-down communication
24	Maintenance regimes for all machinery & equipment
25	Stricter penalties for non-conformance
26	Site layout planning and good housekeeping
27	Enforcing the use of personal protective equipment
28	Allocation of adequate financial resources
30	Safety promotion using a variety of channels

5.2 *Variation ratio and index of diversity*

As discussed previously, the use of VR would facilitate separating the safety culture factors with majority consensus from other factors with no majority consensus as perceived by some respondents as of no consequence to achieving a mature safety culture within their respective organisations.

The VR values identified three factors of absolute majority consensus, and 21 factors considered to be having majority consensus (0.0 < VR <0.5). The ID, on the other hand, reflects the degree of concentration of responses. Table 4 shows the computed VR and ID values for the 27 factors. It also shows the ID values supporting the level of agreement identified in the calculated VR for the majority of factors.

As VR values greater than 0.5 indicate no majority consensus in rating a certain factor as critical, factors 7, 10, 12 & 24 were eliminated from further analysis. The ID value for these four factors reached high values (>0.50) approaching the critical value of 0.66 thus implying a high level of disagreement among survey respondents. Furthermore, factors that had a range value of 2 (i.e. distributed over three categories) and were not identified as critical by the majority of respondents were eliminated from further analysis. Focusing on what the majority perceives as critical is the rationale used herein to eliminate these factors. At this stage, it is worth highlighting the need for stratifying the factors in terms of their importance (i.e. criticality) as explained in the following section.

5.3 *Factors stratification*

Given the obtained three ranges of zero, one and two, as well as the calculated VR of values ranging between zero and 0.5, then it seems to be appropriate to have a four-tier structure for stratifying the safety culture factors. Stratification describes the remaining 18 factors with regard to their degree of impact upon the successful development and achievement of a mature safety culture, according to their perceived criticality. Table 5 presents the factors ranked in an ascending order of their variation ratio (within each category) and the range of these factors. The criteria used in the stratification process are as follows:

Table 4. Variation ratio and index of diversity.

Factor	VR	ID
1	0.00	0.00
5	0.00	0.00
11	0.00	0.00
9	0.03	0.06
20	0.06	0.12
6	0.13	0.22
14	0.16	0.27
2	0.22	0.34
18	0.22	0.34
25	0.22	0.34
21	0.22	0.36
26	0.22	0.36
15	0.22	0.37
28	0.25	0.40
30	0.28	0.44
16	0.31	0.43
23	0.31	0.46
19	0.34	0.49
22	0.38	0.51
4	0.38	0.54
27	0.41	0.48
3	0.44	0.49
17	0.47	0.50
7*	0.50	0.59
10*	0.50	0.59
12*	0.50	0.61
24*	0.56	0.65

*No majority consensus.

Tier 1 safety culture factors are those that are absolutely essential to achieving a mature safety culture as perceived by all respondents. This tier includes three (3) critical factors, which are:

- Safety is considered as important as productivity by all involved;
- Management commitment demonstrated through 'leading by example' on promoting safety issues; and
- Proactive participation in safety by all involved.

Tier 2 safety culture factors are those that are essential to achieving a mature safety culture as perceived by the majority of respondents, while some respondents perceive them as important but not critical. These include:

- Evaluation and selection of subcontractors;
- Clear identification of accountability;
- Management of subcontractors;
- Periodic safety auditing;
- Effective feedback mechanism facilitating bottom-up communication;
- Enforcing the use of personal protective equipment; and
- Employee motivation and empowerment to work safely.

Tier 3 safety culture factors are those that are needed for achieving a mature safety culture (perceived as critical by the majority of respondents). However, these factors were distributed over the three ranges (i.e. zero, one and two). These include:

- Supervisors assuming proactive role in safety;
- Safe behaviour recognised and rewarded;
- Allocation of adequate financial resources;
- Continual safety promotion using a variety of communication channels;
- Effective top-down communication; and
- Proactive on-site hazard assessment.

Finally, Tier 4 safety culture factors are those that have range value of one, and have been perceived as important by the majority of respondents. These include:

- Management of subcontractors;
- Stricter penalties for non-conformance; and
- Adopting zero tolerance as the safety culture standard.

It is worth noting that all the critical factors stratified in tiers 1 and 2 are well known in recent construction safety literature as fundamental and vital elements of safety culture, see Mohamed (2002), Molenaar et al. (2002); Fang et al. (2004); and Tam et al. (2004). However, and contrary to what the literature advocates, factors such as: facilitating team working; providing training opportunities; site layout planning; having documented site safety plans; and including safety in business development goal setting appear to have much lesser degree of criticality. Interestingly, effective top-down communication ranked lower than its bottom-up counterpart.

Table 5. Clusters of the remaining 18 safety culture factors

Factor	Range	Category	Tier	VR
1	0	AC	1	0.00
5	0	AC	1	0.00
11	0	AC	1	0.00
9	1	C	2	0.03
2	1	C	2	0.22
18	1	C	2	0.22
16	1	C	2	0.31
27	1	C	2	0.41
3	1	C	2	0.44
6	2	VI	3	0.13
14	2	VI	3	0.16
28	2	VI	3	0.25
30	2	VI	3	0.28
23	2	VI	3	0.31
22	2	VI	3	0.38
20	1	I	4	0.06
25	1	I	4	0.22
17	1	I	4	0.47

*AC: absolutely critical, C: critical, VI: very important, I: important

6 SELF-ASSESSMENT

The developed survey questionnaire, after the exclusion of the less-critical factors, could be used as a self-assessment tool for assessing and benchmarking the level of maturity of organisational safety culture. This could be useful for organisations in two ways:

First, the 18 critical and important factors provide a realistic checklist for establishing the organisation's current level of safety culture maturity. Second, the tool can be used to assess safety culture understanding among those who are involved, thus identifying improvement actions required to improve the safety culture. Such an assessment is of importance in the appraisal of further improvement requirements. By engaging all those involved in identifying practical actions would definitely help move safety culture maturity to the next level. It is imperative for organisations to develop safety improvement actions matched to their safety culture maturity levels, otherwise these action would simply fail. Furthermore, as safety culture matures, further improvement does not necessarily involve 'more of the same'. The type of culture improvement method needed to support safety culture development differs as safety culture matures (Lardner et al. 2001).

Information gathered from the benchmarking analysis could be used as the basis to prioritize areas for improvement actions. Benchmarking analysis involves the comparison of the degree of implementation of critical and important safety culture factors against agreed-upon targets as described below.

To test whether the more critical the factor, the higher the level of its implementation, respondents were also asked to rate the degree of factors implementation within their respective organisations as a score. It was hypothesised that if respondents per-

ceive a certain factor as being absolutely critical, then the corresponding level of implementation would be close to the maximum score (i.e. 100%), if the safety culture is at a relatively high level of maturity. Adopting a performance scale where 0% reflects the factor not being implemented at all, and 100% as being fully implemented, it was decided to create four (4) convenient implementation regions: >95%, >85%, >80% and >70% corresponding to the absolutely critical, critical, very important and important clusters, respectively. These regions were used as factor-implementation benchmark ranges.

Table 6 lists the average mean scores for implementation levels as reported by survey respondents for the critical Tiers 1 & 2 factors. The table demonstrates that a number of critical factors fell short of the benchmark range creating negative gaps (i.e. not reaching targets set by the organisation or us as independent auditors).

Table 6. Benchmarking average scores for tier 1 & 2 factors

Factor	Tier	Score	Target range
1	1	77	>95%
5	1	82	>95%
11	1	95	>95%
9	2	79	>85%
2	2	89	>85%
18	2	77	>85%
16	2	85	>85%
27	2	89	>85%
3	2	80	>85%

7 CONCLUDING REMARKS

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.

This paper has reported on a research study that attempted to develop a self-assessment tool for benchmarking organizational safety culture. First, the analysis revealed not all factors or determinants of positive safety culture share the same level of criticality. Second, out of 30 documented factors in the literature, the study identified a total of critical and important 18 factors, which impinge on the degree of effectiveness of developing and nurturing a mature safety culture. Three of these factors enjoyed a consensus majority (perceived by all respondents as being critical). The remaining 15 factors had varying degree of agreements about their degree of criticality.

Although this study adds to the extant organisational safety culture literature by identifying and categorizing the critical factors needed to develop and nurture positive safety culture in construction, the study has a specific limitation. It focused on the local industry in Hong Kong, targeted mainly best performers, and presented only the management perspective (ie. objective judgment). Thus the findings may not generalize to other contractors or countries. Further research will need to establish whether these findings are generalizable to other countries.

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