Criteria for the development of a safety culture maturity model for the construction industry

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Abstract

Although it is generally accepted that construction organisations should foster a strong safety culture in order to improve productivity and minimise incidents, little research has been focused on developing instruments to measure the maturity level of safety culture. This paper describes a research study on the development of measurement criteria to assist construction organisations in assessing and understanding their safety culture maturity levels. The components, dimensions, and maturity levels of safety culture were reviewed and measurement criteria for each maturity level in the context of the construction industry were defined. These criteria were aimed at helping construction organisations to determine their safety culture maturity levels, thus giving a starting point to strategise in developing their safety culture. Future research will focus on testing and validating the measurement criteria to determine their practicability.

Keywords: construction management; construction safety; maturity model; safety culture.

1. Introduction

The term safety culture first appeared in the report prepared by International Atomic Energy Agency (IAEA) following a nuclear accident famously known as the Chernobyl disaster in 1986 [1, 2]. Since then, investigations into major accidents and safety failures, such as the Piper Alpha oil platform explosion and the Clapham Junction rail disaster, have revealed mistakes in organisational structures and safety management systems. A public inquiry report argued that poor safety culture was the culprit of the accidents [3, 4]. In fact, Pidgeon [5] described safety culture as the most important theoretical development in safety research.

Safety is a vital aspect in construction projects because it involves the wellbeing and lives of people. Furthermore, safety has become a social and moral responsibility. The norm in present society is that it is the right of every employee to go home safely every day and that employees should not be treated as objects to achieve corporate goals. The reputation of a company is at stake when it does not implement proper safety measures to protect the safety and wellbeing of its employees [6]. Furthermore, since safety is enforceable in law, the lack of a safe environment may lead to prosecution and claims that may incur extra costs, delay the project, cause adverse publicity, and threaten the financial health of a company [7].

The wellbeing and lives of employees as well as social and moral responsibilities are not the only reasons for construction organisations to consider safety. Considerable evidence has been found that safety investment and management is financially profitable [8]. A case study by Zou et al. [9] found that a construction safety risk prevention and reduction program may yield as much as 46% of return on investment. As a counterpoint, 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 [10]. These reasons have given impetus to construction organisations to focus on developing their safety culture.

Nowadays many construction organisations agree that developing safety culture is crucial to implement safety measures and improve safety performance. However, despite this consensus on its value, safety culture research in the construction industry is still relatively limited as compared to other industries, such as oil and gas [11, 12, 13], aviation [14, 15, 16, 17], and healthcare service [1, 18, 19, 20, 21, 22]. One of the key barriers to improving safety culture in the construction industry is the absence of standardised safety culture indicators. Consequently, there is a need to develop an assessment tool for construction organisations to regularly assess their safety culture maturity levels.

The concept of a maturity model has been well developed and accepted. The Software Engineering Institute (SEI) at Carnegie-Mellon University was the first to develop a capability maturity model (CMM) to continuously measure, evolve, and improve processes in software organisations. The development of CMM by SEI started in 1991 when the United States Department of Defence faced problems of poor quality software, missed schedules, and high costs. Thereafter, the CMM approach rapidly gained acceptance in the IT sector and organisations who have successfully implemented CMM have reported significant benefits. Following the success of CMM, the University of Salford began the development of Structured Process Improvement of Construction Enterprises (SPICE) in 1998. SPICE has borrowed many of the basic concepts from CMM to develop a model for construction organisations to identify their current process capability and improve management processes with emphasis processes associated with tendering, design, and construction [23].

There are also several project management maturity models, such as the P3M3 by Office of Government Commerce [24], OPM3 by Project Management Institute [25], and the (PM)² model by Kwak and Ibbs [26]. In the field of risk management, research has been conducted by organisations and researchers, such as Business Risk Management Maturity Model [27], Risk Management Maturity [28], and Ren and Yeo's [29] risk management capability maturity model for complex product system projects. In construction management, Zou et al. [30] developed a Risk Management Maturity Model (RM3) that can be used by construction organisations for assessing and understanding their risk management maturity level, and

developing strategies to improve their risk management practice. Hudson [20, 31] developed a five-level safety culture maturity model. Using Hudson's maturity model [20, 31], Parker et al. [13] provided a description of each maturity level for oil and gas organisations.

Research approach

The key features of organisational and safety culture maturity models were identified from a detailed literature review. These features were then transposed to a construction environment to develop measurement criteria for increasing levels of safety culture maturity.

2. Literature Review on Safety Culture

2.1. A Definition of Safety Culture

Various definitions of safety culture have been proposed by a number of researchers and research organisations including Choudhry et al. [32], Guldenmund [33], and Wiegmann et al. [17]. In this research, the definition adopted was that proposed by Muñiz et al. [34] in which safety culture can be defined as *a set of values, perceptions, attitudes and patterns of behaviour with regard to safety shared by members of the organisation; as well as a set of policies, practices and procedures relating to the reduction of employees' exposure to occupational risks, implemented at every level of the organisation, and reflecting a high level of concern and commitment to the prevention of accidents and illnesses* (p.628). In our view this definition has clarity and portrays the multidimensional nature of safety culture.

2.2. Components of Safety Culture

It is claimed that there are five components that organisations should focus on to improve safety culture, as described in the following sections according to several major references on this topic [35, 36, 37]:

1. Informed culture

This is a cognitive element in an organisation which relates to being alert to the possibility of unpleasant surprises and having the collective mindset necessary to detect, understand, and recover them before they bring about bad consequences [36, p.10]. High reliability organisations strive for system reforms instead of applying local repairs. They recognise that failures can be caused by a wide variety of unknown factors, thus they are alert for novel ways where failures and latent conditions can combine to breach the system defences. Therefore, they are always preoccupied with the possibility of failure. This informed culture allows an organisation to optimally cope with the unanticipated, which is a critical component of organisational resilience. Informed culture has also been described as collective mindfulness [38].

2. Reporting culture

A reporting culture is the prerequisite of informed culture and this can be considered as the most important aspect in safety culture. People must be prepared to report mistakes, near misses, unsafe conditions, wrong procedures, and other safety concerns. This is not about a reporting system in the organisation, but it is whether those things are reported in practice. To create this reporting culture, people should firstly be proactive towards safety by always on the lookout for things that need to be reported and secondly have necessary skills and resources which keep them alert to things that can go wrong [37].

3. Just culture

Just culture determines the effectiveness of a reporting culture. Just culture acknowledges that human beings are fallible, that is, they made mistakes. Therefore, according to just culture, the assessment of risk-taking should not go beyond what can be reasonably expected from fallible human beings [22] although some actions are agreed by all to be totally unacceptable, deserving some retribution [20]. Organisations with just culture are willing to expose areas of weakness to improve their performance. People in these organisations can speak on safety issues regarding their own actions or those of others. They know that they are accountable for their actions, but will not be blamed for system faults in their work environment beyond their control [19]. If an organisation always handles errors with blame and punishment, then reports will cease. Blame should only be reserved for behaviour involving defiance, recklessness, and malice. What is required in this case is not a blame culture, but establishing trust through a just culture. The subsequent subcultures, learning and flexible cultures, largely depend on reporting and just cultures.

4. Learning culture

Reports are a waste of time if an organisation does not learn from them. Therefore, when it comes to safety culture, organisations have to process these reports or any other information conscientiously and make changes as necessary to remedy or improve the situation. Learning is necessary for construction practitioners, especially workers, to perform their work safely [37]. This learning is fundamental for maintaining and improving safety performance in the construction industry. Many organisations consider learning simply as an acquisition of knowledge which can be achieved through instruction and training in a classroom setting. They have a concept that this knowledge is available somewhere and learners need to acquire and store it in proper compartments of their minds [39, 40]. Construction organisations should also recognise the alternative paradigm where safety knowledge and learning are seen as social and cultural phenomena developed through interactions of individuals with each other and with non-human artefacts while working [41]. Therefore, they should create effective social engagements to provide a proper context for learning and improving safety [40].

5. Flexible culture

Lastly, safety culture must also be flexible, which means that decision-making processes are varied depending on the urgency and the expertise of people involved. In this case, people who are best equipped must be the ones who make decisions. For example, if an engineer is the one who has expertise, the director should consult with the engineer first before any decision is made. Organisations with flexible culture reflect changes in demand and adapt rapidly to changes in circumstances, thus providing high tempo and routine modes of operation [20]. In many cases, flexible culture involves shifting from the conventional hierarchy mode to a flatter structure where control passes to task experts on the spot, and

then reverts back to the traditional mode once the emergency has passed [35].

2.3. Dimensions of Safety Culture

Safety culture is multidimensional, a characteristic that has been supported by numerous studies [4, 17, 34, 42, 43]. Health and Safety Executive [4], based on the work by Cooper [44], proposed three distinct but interrelated dimensions of safety culture: psychological, behavioural, and corporate [4]. This three-dimension model has been widely accepted and aligns with the definition of safety culture proposed by ACSNI [45] and Muñiz et al. [34] as well as the theoretical frameworks developed by Clarke [42] and Wiegmann et al. [17].

The psychological dimension of safety culture refers to how people feel about safety and safety management systems. This can be described as the safety climate of the organisation, which encompasses the attitudes and perceptions of individuals and groups at all levels in the organisation [4]. This reasoning indicates that safety climate is part of safety culture, a conceptualisation that has been widely accepted [3, 17, 33, 43, 44]. The behavioural dimension is concerned with what people do within the organisation, which includes the safety-related activities, actions, and behaviours exhibited by employees. Lastly, the corporate dimension can be simply described as what the organisation has, which is reflected in the organisation's policies, operating procedures, management systems, control systems, communication flows, and workflow systems [4].

2.3. Safety Culture Maturity Models

In 2000 a working group on Human Factors from the International Association of Oil and Gas Producers (OGP) met with academics to conduct an OGP culture study. The study developed a maturity model of safety culture which consists of five levels namely pathological, reactive, calculative, proactive, and generative as depicted in Figure 1. This model has been tested and appears to be robust and reliable. It helps define a pathway from less to more advanced safety culture maturity levels [31]. The maturity levels are [20, 31]:

- **Pathological:** safety is a problem caused by workers. The main drivers are the business and a desire not to get caught by the regulator.

- **Reactive:** organisations start to take safety seriously but there is only action after incidents.

- **Calculative:** safety is driven by management systems, with much collection of data. Safety is still primarily driven by management and imposed rather than looked for by the workforce.

- **Proactive:** with improved performance, the unexpected is a challenge. Workforce involvement starts to move the initiative away from a purely top down approach.

- **Generative:** there is active participation at all levels. Safety is perceived to be an inherent part of the business. Organisations are characterised by chronic unease as a counter to complacency.
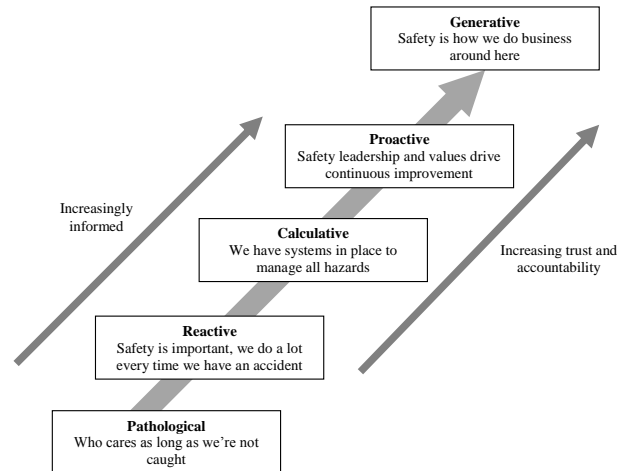

Fig. 1. Safety culture maturity levels [31]

Another model is the Safety Culture Maturity® Model (SCMM) developed by the Keil Centre as part of a project sponsored by the UK offshore oil industry and the Health and Safety Executive (HSE). The SCMM (depicted in Figure 2) aims to assist organisations in establishing their current level of safety culture and identifying the actions required to improve their safety culture. Although originally developed in the context of the UK offshore oil industry, the SCMM has been used successfully in many countries and sectors including aviation, road and rail transport, steelmaking, food manufacture, electronics, and health care [46]. The SCMM has five levels and it is advisable for an organisation not to skip a level as it needs to progress sequentially by building on strengths and removing weaknesses of the previous level. The five maturity levels are [47]:

- **Level one (emerging):** Safety is defined in terms of technical and procedural solutions and compliance with regulations. Safety is not seen as a key business risk and the safety department is perceived to have primary responsibility for safety. Many accidents are seen as unavoidable and as part of the job. Most frontline staff is uninterested in safety.

- **Level two (managing):** Safety is solely defined in terms of adherence to rules and procedures and engineering controls. Accidents are seen as preventable and the majority of accidents are solely caused by the unsafe behaviour of front-line staff. Safety performance is measured in terms of lagging indicators. Senior managers are reactive in their involvement in health and safety.

- **Level three (involving):** The organisation is convinced that the involvement of the frontline employee in health and safety is critical. Managers recognise that a wide range of factors cause accidents and the root causes often originate from management decisions. The majority of staff accepts personal responsibility for their own health and safety. Safety performance is actively monitored and the data is used effectively.

- **Level four (cooperating):** The majority of staff in the organisation are convinced that health and safety is important from both a moral and economic point of view. Managers and frontline staff recognise that a wide range

of factors cause accidents and the root causes are likely to come back to management decisions. Frontline staff accept personal responsibility for their own and others health and safety. The importance of all employees feeling valued and treated fairly is recognised. The organisation puts significant effort into proactive measures to prevent accidents. Safety performance is actively monitored using all data available. Non-work accidents are also monitored and a healthy lifestyle is promoted.

- **Level five (continually improving):** The prevention of all injuries or harm to employees (both at work and at home) is a core company value. There is no feeling of complacency as people live with the paranoia that their next accident is just around the corner. The organisation uses a range of indicators to monitor performance but it is not performance-driven, as it has confidence in its safety processes. The organisation is constantly striving to be better and find better ways of improving hazard control mechanisms. All employees share the belief that health and safety is a critical aspect of their job and accept that the prevention of non-work injuries is important.
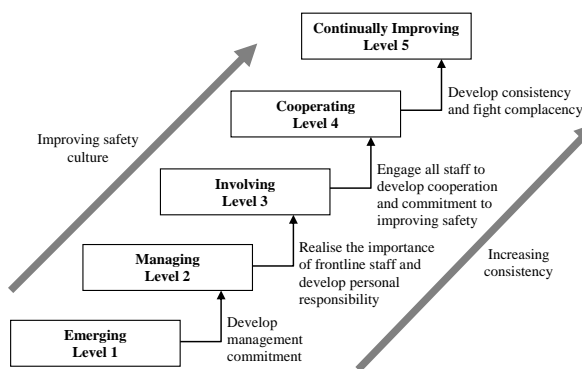

Fig. 2. Safety Culture Maturity® Model [47, 48]

The two models discussed above were considered in terms of the terminology used to describe each safety culture maturity level. In our view each level of maturity must be easily understood to avoid misunderstanding, whilst at the same time, should not create a negative response which would make senior executives reluctant to associate their organisations with lower maturity levels. The safety culture maturity model proposed by Hudson seems direct and blunt, which may not be well accepted by senior executives in the construction industry. Statements like 'who cares as long as we are not caught' and 'we do a lot every time we have an accident' may hinder the accuracy of the model to measure the real safety culture maturity level of a construction organisation. Furthermore, the words 'pathological', 'calculative', and 'generative' are not commonly used in construction industry, thus they may cause misunderstanding or misinterpretation that further reduces the effectiveness of the model.

The SCMM developed by the Keil Centre [47, 48] is better for the construction organisations in terms of labelling each maturity level. They used common words, such as 'emerging', 'managing', 'involving', 'cooperating', and 'continually improving', which can be easily understood. These words are also less "threatening" which should make senior executives

more readily to accept the reality of the safety culture maturity levels of their organisations. Despite these, we felt that some of these words are inadequate to describe the maturity levels accurately. The second level, managing, for instance, may create a misconception as people will think that managing safety can be applied to all maturity levels. The same argument applies to continually improving as it is needed to be implemented at every level so an organisation can progress in its maturity.

In due course, we decided to adopt the SCMM developed by the Keil Centre to represent the five safety culture maturity levels for the construction industry. We felt that this model provides more accuracy due to its less threatening nature and its usage of everyday words. Furthermore, the SCMM has been applied successfully in other industries. Concerning the issue with the label/name of each maturity level, we argued that it is unproductive to focus on semantics, especially since the focus of this research is to develop measurement criteria for each maturity level and develop a measurement instrument (ie questionnaire) to assist construction organisations to measure their safety culture maturity levels.

3. Proposed Safety Culture Measurement Criteria for the Construction Industry

A safety culture framework (Figure 3) was developed by the authors to integrate all the aspects discussed in the previous sections. The components of safety culture consist of just; reporting; informed; flexible; and learning cultures. They impact on the dimensions of safety culture reflected by what people feel (*psychological*), what people do (*behavioural*), and what the organisation has (*corporate*). Thereafter, the next step was to define measurement criteria for each level, in order to assist construction organisations in measuring the dimensions of safety culture underpinned by their components. It is anticipated that by using these measurement criteria, construction organisations will be able to determine their safety culture maturity levels, which should help them strategise in improving their safety performance.

The method of developing the measurement criteria is similar to that undertaken by Parker et al. [13] and Filho et al. [11] where they conducted an exploratory study to generate a theory-based framework that could be used by organisations to understand their safety culture. The framework provides descriptions of each safety culture maturity level for different safety culture dimensions. Some descriptions of the maturity levels were also adapted from their research. However, their research was focused on the oil and gas industry, while our current research focuses on the construction industry. Furthermore, they only described the maturity levels based on the dimensions of safety culture, while in this research, the foundation of safety culture is also integrated into the assessment criteria. Besides these two research studies, a literature review on various safety culture studies [4, 17, 19, 20, 22, 47, 48, 49] has been conducted to develop criteria for each maturity level as presented in Appendix 1.
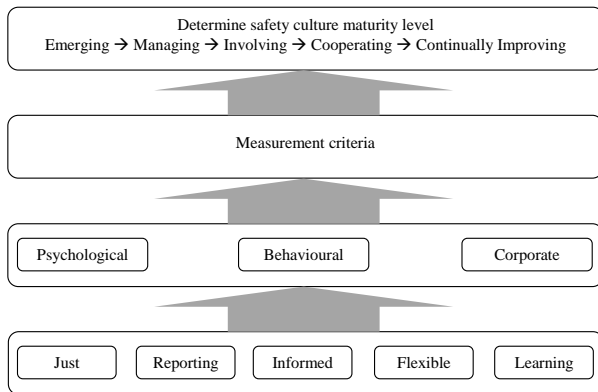
Fig. 3. Safety culture maturity framework for construction

4. Development of Measurement Criteria and Instrument - Questionnaire Design

The measurement criteria discussed in previous sections need to be translated into a questionnaire format. Due to the sensitive nature of the topic (i.e. safety), the questionnaire items have been designed carefully to minimise social desirability bias (SDB), which can arise consciously or unconsciously because respondents may appear to be other than they are. Common types of SDB are the need for approval, ego defence and self-deception where people try to maintain self-esteem, and lastly instrumentation where respondents give answers designed to bring about a socially desirable outcome [50]. The key here is to make the questions less threatening and less blunt/direct, thus the tone of items in the questionnaire is softer than the original criteria in Tables 1 to 5. The efforts included to address this SDB issue are [50, 51]:

- Creating a sense of reassuring that certain behaviour or attitude is not unusual. A statement to demonstrate that the seemingly undesirable behaviour or attitude is common may reduce the threat of reporting it. Of course it is very important for this statement to be reasonable to the respondents, otherwise it will be ineffective and may backfire and increase the threat.

- Providing reasons for not doing socially desirable things such as wearing a hard hat or follow safety procedures. This should help respondents not to over-report such behaviour. On the contrary, an authoritative statement can be used to justify socially undesirable things to minimise under-reporting.

- Using a self-completion questionnaire to ensure anonymity and confidentiality. Many respondents will not appreciate the fact that their responses are likely to be identifiable. It appears that internet-based surveys are being seen by respondents as the most anonymous form of data collection.

Based on the above discussions, the main measurement criteria were translated into a series of questions as shown in the following section, with the letter *a* to *e* representing the five levels of maturity (*a* – emerging, *b* – managing, *c* – involving, *d* – cooperating, *e* – continuously improving). The respondents will choose one answer for each question that reflects their organisation's situation:

1. Accidents happen from time to time in construction projects. What is your view of an accident?
   a. An accident happens because of the mistakes of workers or supervisors.
   b. Accidents are simply bad luck. It is impossible to identify all risks and prevent them from happening.
   c. People failing to follow safety procedures, faulty machinery, and poor maintenance at the worksite level are common sources of accidents.
   d. The whole system should be considered when determining accident causes. It appears that the root causes of accidents are likely to come back to management decisions.
   e. An accident must never happen in my workplace and I am not afraid to report errant behaviours because safety is one of my personal goals.

2. When an accident does happen, what do you think would happen in your organisation?
   a. It is normal for people to look after themselves and shift the blame to other factors.
   b. An accident is an internal issue, thus must be kept undisclosed. An accident investigation or safety audit should be done according to law. It may be necessary for management to remove accident-prone employees.
   c. Management would be upset when an accident happens because it has negative impacts on reputation. A procedure has been established on how people should participate in accident investigation and safety audit.
   d. Management would be disappointed and show care towards the wellbeing of those involved in the accident. People would be cooperative during investigation or safety audit to find the problem and prevent it from happening again.
   e. Management would act swiftly. They would put people and investigation process as their top priority. People would take investigation and audit seriously and personally. Necessary steps to improve performance would be implemented accordingly.

3. Different organisations treat safety performance differently. How does your organisation evaluate safety performance?
   a. As happened in any situation somewhere else, there must be punishment for failure.
   b. It is important to find parties responsible for an accident because poor safety performance should lead to disincentives. Bonuses are tied to lost-time-injury (LTI) performance.
   c. Good safety performance will receive recognition or safety awards. There are periodic safety competitions and quizzes to ensure everyone has sufficient safety knowledge. Total recordable case frequency (TRCF) is used to calculate bonuses.
   d. Safety performance evaluation is based on process rather than outcome. Good performance leads to rewards and is considered as an important aspect in promotion reviews.
   e. A whole system approach including the interaction between systems and people is observed to evaluate safety performance. Good safety performance is intrinsically motivating.

4. It is necessary to report safety issues or discuss about safety in the workplace. What do you feel about this kind of safety reporting and discussion?
   a. Preparing a report on safety is burdensome as there are other objectives in a construction project that need to be taken care of, thus any bad news about safety should be minimised.
   b. As requested by the management, a report is necessary particularly after a major incident or accident.
   c. There is a clear procedure that I have to follow on reporting safety issues and collecting safety data. Safety discussion should be included in project meetings.
   d. I feel accountable to report potential unsafe behaviours and unsafe conditions via the right channel.
   e. Discussing safety issues with all parties involved is a normal thing to do as part of the job. I feel free to report safety issues that come to my attention during the course of the day.
5. People may have their own way of safety reporting and discussions. How do people in your project behave in regards to safety reporting and discussion?
   a. People are aware that safety is a sensitive issue and has negative impacts, thus they typically do not report safety issues unless if it is required.
   b. There are safety personnel on site. They prepare a report especially after an incident or accident.
   c. There is a safety management system and reporting procedure in place so people prepare a report and collect safety statistics as specified by the system and in the procedure.
   d. Management encourages people to report or provide input on safety issues. Although there are safety personnel on site, many people around me are proactive in informing safety personnel concerning potential unsafe behaviours and unsafe conditions.
   e. People at all levels (management and at site) discuss safety issues freely to address safety issues and improve safety performance. Reports and statistics are recorded and available to everyone. All levels actively access and use the information generated by reports in their daily work.
6. How does your organisation manage safety reporting?
   a. I am not sure. I think some investigation takes place after a serious incident or accident.
   b. Reporting is simple and factual. Obviously it is important to find the responsible parties to determine the source of an accident. I believe follow up to track actions after reports and investigations could be improved.
   c. There are fixed procedures and requirements for safety reporting. Safety investigations and audits focus on workplace issues to determine weaknesses for improvement.
   d. Reports offer insight on "why" rather than "what" or "when". Investigations are performed by trained personnel who employ systematic follow up. Reports are distributed companywide to share information and lessons learnt.
   e. Investigation uses aggregate information from previous reports to identify real issues throughout the whole system. A system is established where people can contribute ideas to improve safety performance. Follow up and feedback mechanisms are systematic to ensure that change occurs and is maintained.
7. Conflicts often exist between time, cost quality and safety, when making decision, What is your attitude towards safety?
   a. I believe that accidents are part of the job due to the dangerous nature of the industry. So sometimes you will have to just go for it without much nervous.
   b. Surely safety is important but it is the consideration of safety personnel. Workers like me need to follow what my supervisors or managers wants concerning safety.
   c. There are safety management system and safety procedures that I have to comply with.
   d. I accept the implementation of job safety techniques as standard practice especially since my direct and senior managers are sincere about safety implementation.
   e. Safety is one of key objectives, thus I am accountable and always on alert to monitor potential hazards.
8. Tradeoffs are often made. How do people in your organisation incorporate safety in their work ?
   a. Time and cost are important components in every project. Therefore, it is imperative to employ the quickest and most economical methods to achieve these objectives.
   b. Safety personnel or experts are the ones who put special stress on safety; the supervisors or managers from time to time require some safety measures to be implemented for workers to comply but they are not specially stressed.
   c. People generally perform work according to safety procedures as required by the safety management system. Safety is an objective to managers.
   d. Construction or project managers drive safety implementation because they consider safety as one of priorities. They include safety in all their planning and decision making.
   e. People embrace safety as integral part of the job. Safety is always among the top priorities.

9. What is best described the implementation of safety system in your organisation?
   a. Informal safety management system is implemented. Safety is addressed case by case as required by situation.
   b. Safety calls by supervisors and managers are made for legal issues and workers follow those calls.
   c. There is safety management system in place for managers to take safety into consideration when making decisions.
   d. Safety planning and goals are taken seriously when making decisions.
   e. Safety is always seen as one of the top priorities and everyone get involved in implement safety priorities in their jobs.

10. Who is responsible for safety in your organisation?
    a. I think people involved in an incident or accident are the ones who should be responsible for safety and people should look after themselves to avoid accidents or no one else would do that for you.
    b. There are safety personnel on site who are responsible for safety.
    c. In general, safety personnel are the ones responsible for safety, but we still need to follow safety procedures accordingly.
    d. Project and senior managers are key people in safety implementation. They need to lead safety implementation effectively and give sufficient authority to safety personnel.
    e. Everyone is responsible and accountable for safety. It is also important for people to be willing to embrace change to improve safety performance.
11. How do people in your organisation incorporate safety in their work?
    a. It is important to use common sense. The key is to finish the work on time and on budget. Everyone takes care of their own safety individually.
    b. Workers follow what the manager or supervisor wants about safety.
    c. People follow safety procedures in working and decision making. There are periodical audits by construction or project manager to ensure safety compliance.
    d. Construction or project managers drive safety implementation because they consider safety as one of priorities. They include safety in all their planning and decision making. People are generally committed towards safety because senior managers lead safety implementation and communicate the importance of safety through verbal and written channels.
    e. Everyone is involved in addressing safety issues at work to improve performance. This makes people adaptable to change following what goes well and what goes badly.
12. How does your organisation implement and monitor safety?

    a. My organisation has an informal safety system. Each project may have different implementation and monitoring system depending on the budget and availability of personnel.
    b. Typically management appoints certain individuals to manage safety and solve safety problems. Audits happen after major accidents or incidents but I am not clearly aware of the formal follow ups.
    c. There is a clear structure indicating the responsibilities of safety personnel and other employees at different levels in the organisation. Inspections and audits are structured and conducted regularly especially on known high risk areas.
    d. Safety is an important job given to competent individuals who are highly regarded by project personnel and workers. Construction or project managers should have safety experience, thus they can lead safety implementation effectively.

    e. Safety responsibilities are distributed throughout the organisation because everyone is knowledgeable and skillful concerning safety implementation. People would be cooperative during investigation or safety audit to find the problem and prevent it from happening again.
13. Safety learning and training may not be as useful as it seems to be. What is your attitude towards safety learning and training?
    a. I am not a safety staff, thus I do safety training as required by law so I am eligible to do my job.
    b. From time to time, I participate in safety training as requested by my supervisor or manager.
    c. Safety training is a standard practice and part of my job as stated by the safety management system.
    d. I believe safety training is important and necessary to create a safe working environment.
    e. Besides periodic safety training, safety learning and development is also a continuous process as I do my daily work. It is also necessary for all parties to discuss safety practice and learn from the practical process.
14. How do people in your organisation behave in regards to safety learning and training?
    a. People participate in safety training as required by law.
    b. People do some safety training especially after an incident or accident or as required by the manager and supervisor.
    c. People participate in periodic safety training as required in the safety management system.
    d. Management communicates the importance of safety training. People feel proud to demonstrate their safety knowledge and skills in their work.
    e. Besides participating in formal safety training, people also actively look for and share best practices and ideas to improve our performance and we inform each other about hazards.
15. How does your organisation support safety learning and training?
    a. They provide safety training as required by law.
    b. There is some extra training provided after an incident or accident to remind people of potential hazards.
    c. Safety management system includes clear safety training procedures for everyone in different management levels. Job safety techniques and training are introduced to meet safety management requirements.
    d. Management monitor the effectiveness of safety learning and development program to find ways to improve performance further. There are regular and intensive safety training programs.
    e. People are encouraged to share best practices and safety improvement ideas. Management goes further by collaborating with external parties to work together and improve safety performance.

The above measurement questionnaire should be distributed to all management levels including top management, departmental heads, construction or project managers, engineers and supervisors, and workers. This way, any

misalignment between different levels of management can be identified and the effectiveness of existing safety program can be assessed from a more holistic approach. The final results can be summarised using a spider diagram as shown in Figure 4. This is a convenient approach to determine the overall level of safety culture, thus construction organisations can use the finding as a starting point to find areas of weaknesses and take steps to reach higher safety culture maturity levels.
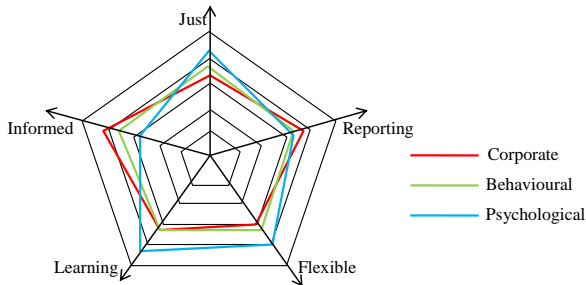

Fig. 4. Spider diagram portraying culture maturity level

Limitation and future research

It should be noted that this measurement criteria and tool, although efficient and easy to be administered, is limited in terms of details. There are other measurement tools that could be used in conjunction to provide in-depth information on the maturity level of safety culture in construction organisations. Zou and Sunindijo [52] revised and developed a safety culture framework for the construction industry and they recommended a safety climate survey comprising six factors: management commitment, supervisor's involvement, training, communication, involvement of staff, and safety rules, to assess the psychological dimensions of safety culture. The behavioural dimension of safety culture can be measured by the level of implementation of safety management tasks. Further, although a questionnaire can be used to assess people's behaviour, it is recommended to also use ethnographic observation method to verify the questionnaire result and get richer data. The last dimension, corporate, can be assessed by controlling and auditing procedures, benchmarking, and data envelopment analysis [52].

Assessing safety culture is most successful when a variety of data collection methods are employed. Documentation reviews, behavioural observations, employee interviews, and questionnaires should be used to gather a richer and more complete picture [4]. Future research, therefore, should focus firstly on verifying the measurement criteria proposed in this paper to ensure their feasibility to be applied in the construction industry. Thereafter, detailed measurement instruments and questions as discussed above should be developed to obtain in-depth information for the maturity level of safety culture in construction organisations. The verification and development can be achieved by several methods including focused expert group workshop, on-site observation and pilot testing.

5. Conclusion

This research has developed measurement criteria to describe safety culture maturity levels in construction by integrating the components and dimensions of safety culture. Five maturity levels are proposed viz. emerging, managing, involving, cooperating, and continually improving. The components of safety culture consists of just culture, reporting culture, informed culture, flexible culture, and learning culture, while the dimensions of safety culture include psychological, behavioural, and corporate. The measurement criteria have been converted into a questionnaire with particular attention paid to social desirability bias issue due to the sensitive nature of the topic. The questionnaire is intended to assist construction organisations to assess their safety culture easily, thus providing them with a starting point to improve their safety performance. The viability of this maturity model has yet to be tested, although given the success of similar models in other industries, it is likely to be successful. Future research in this area will shortly begin to test and validate the proposed measurement criteria and questions.

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Appendix 1

Table 1 Safety culture maturity levels - just culture

		Emerging	Managing	Involving	Cooperating	Continually improving
Just culture	**Psychological**	Workers and supervisors are to be blamed for an accident.	Accidents are bad luck. Some safety commitment after an accident, but diminishes after a period of non accident.	People failing to follow safety procedures, faulty machinery, and poor maintenance are sources of accidents. These have to be addressed at the worksite level.	Safety pride is beginning to develop, thus increasing commitment to safety. The whole system is considered when determining accident causes. Management must take some of the blame when an accident happens because the root causes of accidents are likely to come back to management decisions.	Blame is not an issue. Management accepts they could be responsible for any accident. Everyone is clear about the difference between acceptable and unacceptable actions. People are not afraid of punishment to report errant behaviours.
	Behavioural	People look after themselves and blame one another after an accident.	People attempt to cover up accidents. People reluctantly participate in accident investigation or safety audit as required by the law. Management attempts to remove accident-prone employees.	Management is upset when an accident happen due to its impact on statistics. People participate in accident investigations and safety audit as required in the procedure.	When an accident occurs, management is disappointed, but shows care towards the wellbeing of those involved in the accident. People are generally cooperative during investigation or safety audit.	Management acts swiftly when an accident or incident occurs. They show interest in people and investigation process. People take accidents and safety audit seriously and genuinely implement necessary steps to improve performance.
	Corporate	People take care of themselves as they see fit. There are punishments for failure and no rewards or bunos for good safety performance.	Investigations only focus on finding guilty parties. Poor safety performance leads to disincentives. Bonuses are tied to lost-time-injury (LTI) performance.	Acknowledge good safety performance by lip service or safety awards. Periodic safety competitions and quizzes. Total recordable case frequency (TRCF) is used to calculate bonuses.	Safety performance evaluation is based on process rather than outcome. Good performance leads to rewards and is considered in promotion reviews.	A whole system approach including the interaction between systems and people is observed to evaluate safety performance. Good safety performance is intrinsically motivating.

Table 2 Safety culture maturity levels - reporting culture

		Emerging	Managing	Involving	Cooperating	Continually improving
Reporting culture	**Psychological**	What report? It is a waste of time. People with bad news are "shot".	People have to prepare a report because it is demanded by management.	Preparing a report and collecting safety statistics periodically is a standard practice. Safety discussion is included in the project meeting.	Some people feel accountable to report potential unsafe behaviours and unsafe conditions via the right channel.	Discussing safety issues with all parties involved is a normal thing to do and integral part of the job. People feel free to report safety issues that come to their attention during the course of the day.
	Behavioural	People do not report safety issues.	Certain people (i.e. safety personnel) prepare a report especially after an incident or accident as demanded.	People prepare a report or collect safety statistics according to procedures.	Management encourages people to report or provide input on safety issues. People inform safety personnel concerning potential unsafe behaviours and unsafe conditions.	People discuss safety issues freely to address safety issues and improve safety performance. Reports and statistics are recorded and available to everyone. All levels actively access and use the information generated by reports in their daily work.
	Corporate	There is no reporting system. Investigation takes place only after a serious incident or accident to meet legal requirements.	Reporting exists abut is simple, factual, and focused on finding guilty parties. There is little follow up to track actions after reports and investigations.	There are fixed procedures and requirements for reporting. Investigations normally focus on localised or workplace issues.	Reports offer insight on "why" rather than "what" or "when". Investigations are performed by trained personnel who employ systematic follow up. Reports are distributed companywide to share information and lessons learnt.	Investigation goes a step further by aggregating information from previous reports to identify real issues. A system is established where people can contribute ideas to improve safety performance. Follow up and other feedback mechanisms are systematic to ensure that change occurs and is maintained.

Table 3 Safety culture maturity levels - informed culture

		Emerging	Managing	Involving	Cooperating	Continually improving
Informed culture	**Psychological**	People believe that accidents are part of the job, thus it is natural for accidents to happen. Accidents always happen, it won't change much if safety is taken into consideration	Safety is important, but it is the consideration of safety personnel or experts. Workers just finish what supervisors tell them. Employees feel that they just need to follow what their supervisors or managers wants concerning safety.	It is commonsense to say that safety is important. People have to comply with safety management system but sometimes people have to sacrifies something.	Workers accept the implementation of job safety techniques as standard practice. Managers are seen as sincere when inspecting and auditing safety.	People embrace the importance and necessity of safety at work. Safety is seen as one of key objectives. People's lives should come first. Thus everyone is accountable and always on alert to monitor potential hazards.
	Behavioural	People perform work as quick and as cheap as possible.	Safety personnel or experts are the ones who put special stress on safety. Employees implement safety as required by their supervisors or managers.	People follow procedures according to safety management system. Periodic inspections by construction or project managers to ensure compliance with procedures.	Construction or project managers consider safety as one of priorities and include safety in their planning and decision making. Senior managers lead safety implementation and communicate the importance of safety through verbal and written channels.	People simply embrace safety as integral part of the job. People are actively telling each other about hazards and offer ideas to improve safety performance. Safety is always one of the major concerns that should not be sacrificed.
	Corporate	There is no formal safety management system. Work plan focuses on the cheapest and fastest methods.	Audits happen after major accidents or incidents. There is no formal follow up system. Supervisors and managers make safety calls merely to comply with the law or regulations and workers follow them passively.	Safety management system is in place for managers to take safety into consideration when making decisions. Inspections and audits are structured and conducted regularly especially on known high hazard areas. Job safety techniques and training are introduced to meet safety management system requirements.	Safety planning and goals are taken seriously when making decisions. Extensive safety planning, audit, and training programs are employed as part of effective safety management system, sometimes with outside help to prevent bias and get new ideas.	Safety is always seen as one of the top priorities and everyone get involved in implement safety priorities in their jobs. Job safety techniques are revised regularly in a defined process to achieve best practice. Audit system runs smoothly with effective follow up. Informal search is done continuously to anticipate non-obvious problems.

Table 4 Safety culture maturity levels - flexible culture

		Emerging	Managing	Involving	Cooperating	Continually improving
Flexible culture	**Psychological**	People should look after themselves or no one will take care of them. Nobody is responsible for safety. Those people involved in an incident or accident are the ones responsible for safety.	Safety personnel are responsible for safety. Managers decide what they want and workers just need to follow them.	Safety personnel are responsible for safety while others simply need to follow procedures.	Safety is mainly the responsibility of management. They should lead safety implementation and give proper authority to safety personnel.	Management accepts they could be responsible for any accident. Everyone is responsible and accountable for safety and is clear about the difference between acceptable and unacceptable actions.. People are willing to embrace change to improve safety performance.
	Behavioural	People only care about themselves and do not care about others or safety system. Nobody does anything about safety. Use commonsense to finish the work on time and on budget.	Workers follow what the manager or supervisor wants about safety.	People follow safety procedures in working and making decision about safety issues. Periodic inspections by construction or project managers to ensure compliance with procedures.	Senior managers lead safety implementation and communicate the importance of safety through verbal and written channels. Construction or project managers consider safety as one of priorities and include safety in their planning and decision making.	People commits to safety by taking accidents and safety audit seriously. Everyone is involved in solving safety issues. People are adaptable to change following what goes well and what goes badly.
	Corporate	No system to implement safety and measure performance.	Management appoints certain individuals to solve safety problems after an incident or accident. Follow up is minimal. Audits happen after major accidents or incidents. There is no formal follow up system.	There is a clear structure indicating the responsibilities of safety personnel at different levels in the company. Inspections and audits are structured and conducted regularly especially on known high hazard areas.	Safety is an important job given to competent individuals who are also appreciated by project personnel and workers. Construction or project managers should have safety experience, thus they can lead safety implementation effectively. Extensive safety planning, audit are introduced, sometimes with outside help to prevent bias and get new ideas.	Safety responsibilities are distributed throughout the company because people are knowledgeable and skilful concerning safety implementation.

Table 5 Safety culture maturity levels - learning culture

		Emerging	Managing	Involving	Cooperating	Continually improving
Learning culture	Psychological	Safety training is useless and a waste of time.	People participate in training because it is required.	Safety training is part of the job.	Safety training is important to create a safe working environment.	Safety learning and development is seen as a continuous process rather than periodic events. Discussing best safety practice with all parties involved is a normal thing to do and integral part of the job.
	Behavioural	People do not participate in safety training.	People do some training especially after an incident or accident.	People participate in training periodically as required in the safety management system.	Management supports the importance of safety training. People feel proud to demonstrate their safety knowledge and skills.	People actively look for and share best practices to others. People are actively telling each other about hazards and offer ideas to improve safety performance.
	Corporate	Provide training when it is compulsory by law.	Extra training is provided after an incident or accident.	Safety management system includes clear safety training procedures for everyone. Job safety techniques and training are introduced to meet safety management system requirements.	Management monitor the effectiveness of safety learning and development program to find ways to improve performance further. . Intensive training programs are employed as part of effective safety management system,	People are encouraged to share best practices and safety improvement ideas. Management goes further by collaborating with external parties to work together and improve safety performance.