Determination of Elements for Technical and Vocational Education and Training (TVET) Safety Culture Maturity Measurement Preliminary Framework

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doi: https://doi.org/10.21467/proceedings.141.24

ABSTRACT

Occupational safety is vital and should be prioritised in the public sector's critical performance agenda. Strong safety culture is able to address safety issues. In researching safety culture measures, education sectors such as technical and vocational education and training (TVET) remain ambiguous. This paper describes the work undertaken to develop and evaluate the components of a preliminary research framework for assessing the maturity of safety culture in TVET institutions, i.e., polytechnics, by adapting the existing safety culture maturity (SCM) model with local guidelines documents to the studied organisation. Experts consented to participate in this study and validated the proposed elements under four primary constructs using the Fuzzy Delphi Method (FDM). The proposed elements must adhere to three FDM principles to be retained: 1) Threshold value (d) ≤ 0.2, 2) Expert Consensus Percentage > 75.0% and 3) Fuzzy score (A) value of α - cut = > 0.5. The construct's threshold (d) value is also accepted with the value (d) 0.2 or less. The selected elements are then used to develop the subsequent phase's framework content. The identified elements are used as components of a preliminary research framework and as an initial point for the established SCM measurement framework for the Polytechnic.

Keywords: *SCM, TVET, Preliminary Research Framework.*

1 Introduction

Utilising technical laboratory activities and demonstrations is crucial to effective science education. Physical hazards, electrical hazards, mechanical hazards, biological hazards, and ergonomic factors are frequent in the technical lab. Laboratory accidents and near misses (such as fires, leaks, explosions or explosions of glassware, spills, and misuse of equipment or instruments that cause equipment to break but no one is injured) are common [1]. They should be made aware by lab users. Even though numerous science-related activities can potentially be hazardous, employing reasonable safety procedures and fostering a positive safety culture reduces the likelihood of accidents [2]("Creating Safety Cultures in Academic Institutions," 2012).

In Malaysia, the Department of Occupational Safety and Health (DOSH) Malaysia reported 3,666 workplace accidents in 2016. The number of cases decreased to 3,635 (0.8%) in 2017 before rising to 5,031 in 2018 and 6,933 in 2020 [3] (DOSH, 2019). From 2014 to 2018, the occupational death rate exceeded four before falling below four in 2019. The Social Security Organization (SOCSO) report for 2016 to 2019 revealed that the education sector reported between 350 and 385 accidents yearly [4]–[7]. The increasing number of cases will likely continue over the next few years.

Proceedings DOI: 10.21467/proceedings.141; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-957605-4-1

According to the available data, the construction and manufacturing industries had the highest rates of occupational injuries and fatalities compared to other sectors [8]. Typically, fewer workplace accidents occur in the education sector than in the manufacturing and construction industries. However, the annual workplace accidents reported in the education sector are rising. By enacting the Occupational Safety and Health Act (OSHA) in 1994, self-regulation was primarily introduced to foster a workplace safety culture [9].

1.1 TVET institution environment.

In general, TVET is an education that includes general education, technology theories, and practical skills related to the industry. As Malaysia's economy has grown robustly in recent years, the availability of technically competent and skilled workers has become increasingly important yearly. Since 2015, the government has recognised the need for high-skilled human capital in local industries. It has begun to focus heavily on the Technical Vocational Education and Training (TVET) sector, intending to make TVET the primary source of high-skilled workers [10]. It is an essential factor in the future production of quality employees [11]. It serves as a link between education and industry.

The Polytechnic is one of the governments TVET institutions under the Ministry of Higher Education (MOHE). Currently, 36 polytechnics are spread across different states in peninsular Malaysia, including Sabah and Sarawak. One of the original polytechnics established is one of the earliest TVET institutions in Malaysia. Electrical, civil, and mechanical engineering programmes are among those available. As a result of the fact that polytechnics offer these types of programmes, the laboratories on campus are stocked with dangerous chemicals, heavy machinery, and other forms of cutting-edge, hands-on equipment, which puts users in the lab in danger from a wide variety of threats. Safety Culture Maturity.

1.2 Safety Culture Maturity

Safety culture is defined as the organisation's values and beliefs that govern how people should work and behave [12]. According to a previous study [13], [14], an organisation's safety culture maturity can be used to determine its existence and effectiveness.

The evolved safety culture model, in which it goes through stages of maturity [13], [15], appears to be an acceptable alternative because, in terms of intermediary stages, it allows progress to proceed in manageable steps rather than requiring a significant leap into what might be unknown. Since the evolutionary model is predicated on the notion that the safety culture progresses through stages of maturity, the safety culture matures in stages [16]. In addition, it is one of the methodologies that has received the most attention in the research community. Such an analysis leaves the TVET education sector ambiguous. In addition, fewer measures have been established to evaluate employees' safety culture [17]. Consequently, this paper presents a potential preliminary research framework for developing a detailed SCM measurement framework through experts' consensus that can be used within TVET institutions, namely, Polytechnic.

The preliminary research framework uses five levels of Safety culture maturity adapted from Hudson's safety culture maturity model [18]. The formulation is as in figure 1:

Level 1 Pathological

"Safety is not important to us" - Still, attitudes toward safety concerns are low. As long as safety concerns have not affected anything or anyone, there is no reason to address them.

Level 2 Reactive

"Safety is essential. We do a lot every time safety is a significant concern, and appropriate actions will be taken in the event of an accident.

Level 3 Bureaucratic

"We have systems in place to manage all hazards" -There is a safety system in place to manage all hazards. Organisational goals can sometimes take precedence over safety.

Level 4 Proactive

"We work on the problems that we still find" -Efforts are being put in the direction of solving the problem which can still be found. There is a clear demonstration of a continuing commitment to occupational health and safety.

Level 5 Sustainable

"Safety is how we do business around here" -Safety and health are valuable, and risk management is how businesses operate. The impact on the environment is also considered.

2 Method

To base the SCM Model on the framework to be developed, a review of publications describing capability maturity models used in other domains such as oil and gas, construction, and healthcare, as well as usability, was conducted. OSH documents published by DOSH and Malaysian standard documents containing general safety procedures have been reviewed to establish key elements of the organisation's safety culture. Through literature studies, an author [20] investigated the safety maturity model developed previously in petrochemical industry [21] and employed in an education sector lab. The information obtained from the aforementioned sources was used to draught the first version of the SCMM in this study, which consists of four primary dimensions: Information, Organisational Learning, Involvement, Communication and Commitment, 22 initial elements, and eight new elements. Experts evaluate the suitability of this component under each dimension and as a component of the preliminary research framework.

3 Theory and Calculation

This research adopted the Fuzzy Delphi method (FDM) to achieve experts' consensus. In a previous study, Hsu and Yang [22] established the Fuzzy Delphi Method using fuzzy triangular numbers to incorporate expert opinions. This method's simplicity lies in the fact that all expert opinions can be incorporated into a single investigation. As a result, this method may produce a more practical criteria selection. The data analysis is based on fuzzy triangular numbers to determine the threshold value (d).

Consequently, the first requirement is that the threshold value (d) must be less than or equal to 0.2 [23]. The second requirement that must be followed states that the level of the expert agreement must be at least 75.0 per cent [24]. And the final requirement is that the fuzzy score (A) value must be greater than or equal to the median value (- cut value) of 0.5 [25].

Experts were identified and invited to validate the appropriate elements in the studied organisation. Experts must be selected among those with the relevant skills [26]. In the context of this study, safety, occupational health, or the commonly used term, OSH, are defined. The researcher's criteria were evaluated and agreed upon by two experts in the field. The experts' requirements are:

(1) experts working as lecturer or personnel in related fields (safety/OSH/SHE); or
(2) experience in related research (safety/OSH/safety culture); or
(3) experience and knowledge of safety practices/safety culture/safety acts and regulations and have working experience of more than five years; or
(4) at least a master's degree in safety/OSH/SHE.

Proceedings DOI: 10.21467/proceedings.141
ISBN: 978-81-957605-4-1

Series: AIJR Proceedings
ISSN: 2582-3922

Experts who volunteered their time and agreed to participate in this study have more than five years of experience in occupational safety and health. A set of questionnaires formulated through a literature review was developed and emailed to the experts. They were instructed to indicate their level of agreement for each element using a seven-point Likert scale, with one (1) indicating strongly disagree and seven (7) indicating strongly agree.

Triangular Fuzzy Numbers (TFN) permitted the translation of each expert's Likert scale-based response into fuzzy scoring. The score is converted to fuzzy scores with minimum, most reasonable, and maximum values of 0.9 and 1.0, respectively (Table 1). It indicated that the percentage of experts who agree with the item is 90% and 100%, respectively. The Research Ethics Committee of the Universiti of Malaya granted ethical approval for the study. The participants' consent was obtained using an information sheet. Participants were informed that their participation in the study was voluntary, that they could withdraw from the study at any time without repercussions, and that confidentiality would be maintained at all times.

As indicated by the Fuzzy number = m (m1, m2, and m3) values, the fuzzy scores were averaged for the Defuzzification process (Table 1). Following successful completion, each answer sheet was emailed to the primary researcher. Experts are welcome to write their thoughts based on their knowledge and experience as practitioners, academics, or experts in OSH regulations and training. Finally, the selected element is one on which consensus has been reached.

4 Results and Discussion

The safety culture maturity elements listed by Goncalves [27] and two local guideline documents were referred to identify potential safety culture maturity components. The two documents are the Occupational Health and Safety Management System - Requirements with Guidance Use [28] and the Guideline of Occupational Safety and Health Management [29]. These references were the sources from which the elements that now make up the preliminary framework were adopted and adapted. Expert consensus was reached on the inclusion of elements that were retained and included in the preliminary measurement framework refers to the element conditions through FDM.

Table 1: *The seven variable linguistic scale*

Linguistic Variable	Likert Scale	Fuzzy Scoring		
Strongly Agree	7	0.9	1	1
Agree	6	0.7	0.9	1
Somewhat agree	5	0.5	0.7	0.9
Neither agree nor disagree	4	0.3	0.5	0.7
Somewhat disagree	3	0.1	0.3	0.5
Disagree	2	0	0.1	0.3
Strongly disagree	1	0	0	0.1

All experts provided responses at a rate of one hundred per cent. Each item within the principal dimensions has been rated. The average Likert score is between five and seven, which corresponds to moderately agree to strongly agree. This score has been transformed into a fuzzy number. Following FDM analysis (Table 2), the first requirement is satisfied when all four constructs have a threshold value of (d) 0.2 or less.

Table 2: *Example Summary of Fuzzy Delphi Findings.*

	Triangular Fuzzy Numbers Terms		**Fuzzy Evaluation Process**		
Dimension/Elements	***Threshold value, d***	**Experts Agreement percentage %**	**m1, m2, m3**	**Skor *Fuzzy (α)***	**Experts Agreement**
Dimension: Information	0.01				
Attitude toward accident & incident	≤0.2	> 75%	(0.75,0.89,0.96)	> 0.5	Retained
Information channel mechanism	≤0.2	> 75%	(0.75,0.91,0.98)	> 0.5	Retained
Degree of comfortability	≤0.2	> 75%	(0.76,0.91,0.98)	> 0.5	Retained
Index Monitoring	≤0.2	> 75%	(0.72,0.88,0.96)	> 0.5	Retained
Dimension: Organisational Learning	0.01				
Analysis of the information	≤0.2	> 75%	(0.78,0.92,0.99)	> 0.5	Retained
Investigation objective	≤0.2	> 75%	(0.65,0.83,0.94)	> 0.5	Retained
Investigated actions	≤0.2	> 75%	(0.69,0.85,0.95)	> 0.5	Retained
Dissemination of action	≤0.2	> 75%	(0.70,0.87,0.97)	> 0.5	Retained
Safety performance	≥0.2	< 75%	(0.61,0.77,0.89)	> 0.5	Discarded
Management of change	≤0.2	> 75%	(0.73,0.89,0.98)	> 0.5	Retained

Regarding the element threshold value, two elements have values above 0.20. Regarding the second criterion, the expert consensus must be greater than 75% for each retained item. The third requirement roles a position item in the construct by calculating the fuzzy average number and it must be greater than 0.5. These three conditions must be met.

The purpose of this study is to present a preliminary research framework as a guide for developing the SCM framework for Polytechnics. The component investigated a model applied in the education environment as well as the elements studied in the OSH system management document locally. Experts' consensus was required to determine the proposed elements, which were then used as a reference to develop the framework in detail in the following phase. 30 SCM elements were validated, and only components that met FDM requirements were retained. The next step in the process is to develop SCM framework content for each element.

There are several ways to formulate a component or item through expert consensus. It depends on some variables, including timing, personal expertise, and financial considerations. This study was conducted during a period of movement control order (MCO), so it was deemed suitable to collect data remotely using email. To achieve a high response rate, it was necessary to send several friendly reminders.

5 Conclusion

This study's process facilitates the integration of diverse expert backgrounds in terms of knowledge, years of experience, and relevant skills. In this context, the suitability of the components can be determined after the variety's opinions are merged to produce the result and whether the appropriate elements are included in the initial framework of establishing the SCM Polytechnic framework.

However, this study has several limitations. It will only concentrate on a single TVET institution, Polytechnics. Future expansion could target other TVET institutions and educational institutions in Malaysia.

6 Declarations

6.1 Acknowledgements

The authors would like to acknowledge the support of officers from the Department of Safety and Health, Malaysia and the National Institute of Occupational Safety and Health, including Ts. Hj Mohd Esa Baruji, Mr.Azhar Ahmad and Mr Shahronizam Noordin.

6.2 Ethical Approval

The author received ethical approval from Universiti Malaya Research Ethics Committee (UMREC). Reference Number: UM.TNC2/UMREC_1251.

6.3 Competing Interest

The authors involved in this work have no conflict of interest.

6.4 Publisher's Note

AIJR remains neutral with regard to jurisdiction claims in published maps and institutional affiliations.

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