ORIGINAL ARTICLE

Factor Analysis Approach for Measuring Safety Culture in Research University in Malaysia

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ABSTRACT

Introduction: Safety culture is an important factor for improving safety in university. This study aimed to examines the construct validity and reliability of the elements of safety culture in research universities in Malaysia. **Methods:** A measuring instrument was developed and analyzed for reliability using an exploratory factor analysis approach. The reliability analysis was determined using Cronbach's Alpha. About 298 postgraduates' students from five research universities were selected randomly. An exploratory factor analysis was performed using the principal component method with varimax rotation, Kaiser Meyer Olkin, Bartlett's test of Sphericity and Cronbach's alpha were obtained. Statistical analysis was carried out using the Statistical Package for Social Science (SPSS) and Analysis Moment of Structures (AMOS) version 24.0 (IBM SPSS-AMOS V24.0) software. **Results:** Findings indicated that the Keiser-Meyer-Olkin for all elements of safety culture (training, leadership, management commitment and communication) was in the range 0.799 and 0.916, in which the value was greater than 0.70, while Barlett's test with a p value of 0.000. Factor loadings were greater than 0.60 in all elements of safety culture. Cronbach's alpha coefficient was at the range of reliability between $0.8 < \alpha < 0.9$. **Conclusion:** It can be concluded the instrument was found to be a potential mechanism for measuring safety culture in research universities in Malaysia. .
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INTRODUCTION

In Malaysia, five public universities accredited by the Malaysian government on 11th October 2006 categorized as Research Universities (RUs) are namely Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM) and Universiti Teknologi Malaysia (UTM) (1). These universities are responsible for research and development activities as well as commercialization (2) with the ultimate objective to develop the nation's New Economic Model base on innovation and creativity (3). However, even RUs main responsibility more focuses on research, development and commercialization activities, the issues of occupational safety and health also become more important in university (4). This is due to the various field of study such as sciences, technology and engineering offered by the universities.

Most people have a perception that university laboratories provide a secure environment for work and study. However, the truth is that the majority of these laboratories are actually unsafe settings for both work and study (5-6). This can be seen from the statistics on incidents in university laboratories which indicates that the accidents rate is 10 to 50 times higher than in industrial laboratories (7-8). For example, about 49% of laboratory accidents were related to improper use of chemicals in the last three years in Taiwan (9). The US Chemical Safety and Hazard Investigation Board (CSB) has reported 120 academic research laboratory accidents resulting in 87 evacuations, 96 serious injuries and three deaths since 2001 (10). In another related report, an accident took place in the organic chemistry laboratory of the University of California, Los Angeles

(UCLA) on December 29, 2008. Tragically, a research assistant lost her life as a result of third-degree burns and additional complications. It was discovered that she had neglected to wear a laboratory coat while handling a pyrophoric chemical (11-12).

Furthermore, a chemistry professor at Dartmouth College (USA) succumbed to mercury poisoning when a minute droplet of dimethylmercury permeated her latex gloves. Subsequent investigations revealed that the latex gloves she had used were inadequate for handling dimethylmercury safely (13). A study conducted by (14) at Iowa State University between 2001 and 2014 discovered that laboratory accidents, encompassing both teaching and research labs, accounted for 18.4% of all reported incidents. Additionally, the study revealed that student employees constituted one-third of the injury reports, indicating they were frequently the victims of these accidents. While, in the RUs, several chemical accidents were reported which involve laboratories in UM (2001), UPM (2002) and UKM, (2005) (15-16), whereas USM reported to have 36 accidents in 2004 resulting in minor injuries such as wound cut by knife, finger fractures and etc. (17).

It seems clear that university labs are as dangerous as those industrial labs, because of lower safety enforcement in universities (18). According to (7), many laboratory activities create safety hazards such as biological, chemical, corrosive, explosive, flammable, physical, radiological and toxic agents in university labs. Besides, laboratory's accident often occur due to various factors such as ignorance negligence, carelessness, poor of machinery or equipment, risky behavior, poor of operating systems, lack of enforcement and disobey safety rules (19-21). In addition, poor of laboratory safety practices have the potential for causing laboratory accident and also severe injuries among the laboratories users (7). The laboratory accidents primarily arise from human attitudes and the accumulation of knowledge and experience. These factors influence how individuals respond when faced with specific stimuli within a laboratory setting (22).

Although safety and health are always been guaranteed by the university through certain rules and codes of conduct, however, it cannot be implemented accordingly, even accidents and injuries often occur to employees and students (4). Thus, safety and health issues need to be addressed by organizations, especially those involving the field of science (23). Safety issues are not only the responsibility of top management but all parties need to play a role (24). In fact, OHS issues now become as the human rights of the people of an organization and has not considered as privilege anymore (25). Accidents and injuries at workplace can effects human resources and the skills (26-27). Consequently, it is imperative to provide individuals with adequate information regarding the hazards present in a laboratory environment. Furthermore, it is crucial to ensure that the necessary precautions are taken to mitigate these risks (28–30).

Safety is an integral part of all laboratory operations but it requires that laboratory users considers this every time they start work (1). Instilling the significance of laboratory safety in students from an early stage is vital. It should be reiterated frequently and should never be disregarded or underestimated (31). Safety culture is the prime importance in laboratory practices at many university laboratories (32). Fostering a positive safety culture can serve as a powerful mechanism for enhancing safety within an organization, while also cultivating a favorable atmosphere in the workplace (33-34). Several studies have provided evidence that a strong safety culture yields beneficial outcomes, including reduced accident rates and enhanced safety (35). Furthermore, it has been established that a robust safety culture actively contributes to long-term advantages such as increased productivity and lowered costs (36).

Safety culture plays a pivotal role in guiding individuals to recognize and appreciate the significance of maintaining a safe working environment (37). Moreover, in an academic environment, laboratory safety holds even greater significance in the long run as it is where future workers are being trained. Therefore, the purpose of this study was to design a valid and reliable instrument based on the four elements of safety culture, which are training, leadership, management commitment and communication among postgraduate students in RUs in the Malaysian context.

MATERIALS AND METHODS

The present study was conducted to examine the validity and the reliability of safety culture questionnaire using exploratory factor analysis (EFA) from safety culture perspective in the RUs in Malaysia. About 298 postgraduates' students from Faculty of Science in five RU's (UM, USM, UKM, UPM and UTM) were selected randomly. According to (38), a sample size of 298 is adequate to represent the total population of 1,357. The data collected were analyzed by using Statistical Package for Social Science (SPSS) and Analysis Moment of Structures (AMOS) version 24.0 (IBM SPSS-AMOS V24.0). This study was conducted by using the quantitative method which the closed-ended questions. A 68-item questionnaire was developed consisting of training (20 items), leadership (17 items), management commitment (15 items) and communication (16 items) based on the comprehensive literature review, addressing the safety culture elements (39-40).

The factor analysis and the reliability of the instruments was used under this study. The data were analyzed using the Keiser-Meyer-Olkin (KMO) and Bartlett's test. The adequacy of the sample is measured by KMO where if the values range between 0 and 1 whereby a value close to 1.0 indicates greater suitability, and amount greater than 0.60 is considered good (41-42). The strength of the relationship can be assessed using a Bartlett's test. If the resulting significance value is less than 0.05, it signifies that the data does not conform to an identity matrix, suggesting approximate multivariate normality. Such results are considered acceptable for further analysis (41).

Subsequently, factor analysis was employed as a multivariate analysis technique to uncover potential underlying factors that contribute to the co-variation observed among the independent variables within the group (43). A factor analysis using Principal Component Analysis (PCA) was then conducted to observe variables by a smaller number of factors, and the factors were extracted using the Varimax rotated principal component method to produce the uncorrelated extracted factors with the eigenvalues greater than 1.000 (41). The exploratory factor analysis (EFA) was applied to the four elements of safety culture in the questionnaire. In order to evaluate the reliability of the measures, Cronbach's Alpha was computed to assess the consistency of variables retained within each factor. Coefficients exceeding 0.70 were deemed acceptable, indicating a strong construct reliability (41). Table I shows the rating scale of instrument quality criteria (42). The approval and ethical clearance from the Faculty of Applied Sciences (UiTM) was attained upon commencement of the study [Reference No: FERC/FSG/22/088].

Table I: Rating scale instrument quality criteria

Cronbach's Alpha	Internal Consistency
α ≥ 0.9	Excellent
0.9 > α ≥ 0.8	Good
0.8 > α ≥ 0.7	Acceptable
0.7 > α ≥ 0.6	Questionable
0.6 > α ≥ 0.5	Poor
0.5 > α	Unacceptable

Source: De Vellis (2012) and Pallant (2013)

RESULT

EFA with the varimax rotation of 68 items of safety culture elements (rules and procedures, safety policy, reward systems and involvement) was conducted (n= 298). The results of the EFA on the four elements employed in this study are presented as follows. Table II indicate that the sampling adequacy measure of KMO for all elements of safety culture was in the range 0.799 and 0.916, in which the value was greater than 0.70 (41, 42). Meanwhile, the Bartlett's test of sphericity was significant for all elements of safety culture, with a p-value of 0.000 ($p = 0.000 < 0.05$). Both results suggest that the data value of 298 is adequate and considered more suitable for factor analysis.

Table II. KMO and Barlett's Test of Safety Culture Elements

KMO and Barlett's Test	Measure of Sampling Adequacy	Barlett Test		
		Approx.	df.	Sig.
Training	0.816	1343.648	28	0.000
Leadership	0.916	2321.421	55	0.000
Management commitment	0.876	1825.721	35	0.000
Communication	0.799	1254.332	66	0.000

Table III presents the outcomes of the factor analysis conducted on the safety culture elements employed in this study. For the training elements, principal component analysis (PCA) revealed the extraction of four component dimensions with eigenvalues surpassing 1.0. These four components, in terms of the cumulative extracted sums of the loading value, account for 73.6% of the elements. Similarly, for the leadership elements, PCA identified three components with eigenvalues surpassing 1.0, and the cumulative extracted sums of the loading value indicate that these components explain 65.7% of the elements.

Table III: Factor analysis for safety culture elements

Elements of Safety Culture	Number of Component with Initial Eigenvalues more than 1.000	Cumulative Rotation Sums of Squared Loading	Cronbach's Alpha
Training	4	73.6%	0.921
Leadership	3	65.7%	0.879
Management commitment	3	62.6%	0.901
Communication	3	71.9%	0.814

Regarding the management commitment elements, three components were identified with eigenvalues surpassing 1.0. The cumulative rotation sums of squared loading values indicate that the two extracted components explain 62.6% of the reward systems elements. As for the communication elements, PCA extracted three component dimensions with eigenvalues exceeding 1.0. The cumulative rotation sums of squared loading values indicate that these three components explain 71.9% of the elements.

Based on the Cronbach's alpha value, it was determined that all constructs demonstrated reliability, exhibiting good internal consistency. Furthermore, among the four constructs, excellent internal consistency was observed. Internal consistency found in this study for training, leadership, management commitment and communication at values of 0.921, 0.879, 0.901 and 0.814, respectively (Table III). The analysis results indicate that the constructs of training, leadership, management commitment, and communication exhibit reliability within the range of 0.8 < α < 0.9, indicating good to excellent levels of internal consistency. Overall, all item from each construct are maintained with all item fulfill with the requirement reliability value (more than 0.7).

DISCUSSION

Elements of safety culture differ from study to study (44). The elements of safety culture encompass management, commitment to safety, willingness to raise safety concerns, decision-making, supervisor's responsibility for safety, questioning attitude, safety communication, personal responsibility for safety, prioritizing safety, and safety training (44). Study done by Schlesinger (45), revealed that training is an opportunity to engage employees and mold their behavior to the desired outcomes of the solution. Training acts as a mediating factor exclusively between safety knowledge and safety performance (4). Employees who engage in training will effectively apply the acquired knowledge if they perceive its relevance to their work activities (4). Training exhibits a connection with injury management within the workplace and yields a significant influence on employees' performance in fostering a safer and healthier work environment (1).

Leadership is one of the key success of safety culture and it can be demonstrated together with management commitment (32-33). To uphold a safety culture, it is essential for leaders to demonstrate continuous and visible support for everyday safety measures while actively promoting their importance (1). According to (46), there is a positive relationship between safety management commitment and both safety compliance and safety participation. The successful transformation of safety culture necessitates clear management commitment that permeates throughout the entire organization (4).

An effective communication is vital to engage workers in safety activities, to retain a positive culture, and to achieve support and cooperation (1,47). Effective safety communication has been shown to affect safety performance and would more or less affect the occurrence of human factor accidents at the workplace (47-48). For communication to be effective, it relies on employees' willingness to openly share information and provide feedback to top management. This enables a deeper understanding of needs and challenges. Equally important is the top management's willingness to actively listen and take prompt action to address the issues at hand (49).

CONCLUSION

The present study showed that the training, leadership, management commitment and communication is a highly valid and reliable instrument to measure safety culture among postgraduate students in RUs in the Malaysian. A review of the reliability and validity of the content of the instrument indicate that all item from each construct are acceptable for the safety culture instrument which can be used by RUs to seriously prevent addressing safety and health issues among postgraduate's student. This study makes both theoretical and contextual contributions to the understanding of safety culture in university settings. Theoretical and contextual significance lies in the development of a framework that guides the comprehension and advancement of safety culture as well as focusing on the unique context of a university environment. It serves as a valuable resource for enhancing safety culture practices and mitigating safety-related incidents. However, this study is limited to the views of science students in RU's universities in Malaysia context and it needs to be validated in other contexts.

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