

Exploratory Analysis of Ergonomics Importance at Workplace and Safety Culture Amongst Occupational Safety and Health Practitioners

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Abstract This paper is a revised and extended version of a paper that was presented at WCE 2012. The article reports on a study to identify key components which can be used to relate ergonomics awareness and safety culture. These components can be used to facilitate the research which is aimed at determining the elements that influence the ergonomics awareness and the relationship with safety culture in an organization. A survey was done using a sample of 108 OSH practitioners in manufacturing companies in Malaysia. Exploratory Factor Analysis was used to determine the importance of ergonomics at their workplace and their beliefs on the importance of safety culture to be inculcated at their companies. 3 factors for ergonomics importance were identified: (i) Implication of & Need for improvement, (ii) Fitting the job to the workers and (iii) Basic ergonomics consideration. Safety culture questions were focused on the OSH practitioners perceptions on safety climate importance. Three constructs were designed: (i) commitment and leadership, (ii) motivation and (iii) safety management system practice. This finding is significant in order to study the influence of the perceptions of OSH practitioners on ergonomics importance at workplace to the safety culture.

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1 Introduction

Safety culture is defined as ‘a set of value, perceptions and attitudes and patterns of behavior [1–4]. Ergonomics is a scientific discipline concerning with the understanding of interactions among humans and other elements of a system and it will contribute to job satisfaction [5]. In safety, all situations must be in ergonomics compliance such as equipment, control panel and Personal Protective Equipment (PPE) (e.g. helmet, goggle, belt, shoes). Thus, ergonomics awareness is very important and it is prove to have substantial impact on the industry, organization, management, employees and overall well-being of the system [6]. Ergonomics awareness helps in ergonomics application and contributes significantly to human well-being and safety.

2 Conceptual Background

Even though ergonomics is listed under safety and health, they are actually in two different issues.

For example, safety hazard is easy to identify based on the moving machine, breaking of any ropes, height while ergonomics hazard is difficult to be identified. It is based on work methods such as repetitive movement, heavy lifting, awkward posture [7]. It needs high awareness to put ergonomics risk as priority [8]. The effect of safety is shown as acute effect while ergonomics is chronic effect—takes time to get the effect [7]. Many ergonomically related injuries can progress to long-term or may give permanent disabilities if not taken care of properly. The ergonomics risk may appear after retirement [8]. The effect of the safety hazard can be seen in forms of injury such as wounds, cuts, burns while ergonomics hazard can be seen in forms of Musculoskeletal Disorders (MSDs) and Carpal Tunnel Syndrome (CTS) [8]. The injuries is primary injuries based on Heinrich (1941) while ergonomics is secondary injuries. For example, overexertion often results in muscular or thermal exhaustion; but lifting too much weight can tear tendons from the bone, and introduce bone fragments into soft tissue [9]. Once damaged, tendons and ligaments heal slowly. This type of secondary injuries would not have happened without the original injury [9]. Medical certificate (MC) and compensation will be given by company when safety accident occur but for ergonomics there are trend of, absenteeism and MC that can show the occupational ergonomics risk [8]. For the regulations, safety has clear regulations while ergonomics is lack of specific standard, for example, for awkward position situation depends on the capability of the company’s Safety and health practitioner which refer to OSHA Sec 15 [10], general duties of employers: to ensure so far as is practicable, the safety, health and welfare at work of all his employees.

The study of differences between safety and ergonomics may emphasize why OSH practitioners do not aware the immediate importance of ergonomics. Hence, ergonomics awareness is important amongst OSH practitioners to ensure the implementation of ergonomics. The study on ergonomics awareness was determined through some literature review and discussions with experts. There are a variety of methods that have been used to assess ergonomics awareness. Unfortunately, no standard measurement available that can be used to build a construct. Some issues that OSH practitioners need to be aware are the extent of implications of ergonomics, the extent of suitability of jobs to the workers, equipment used [11], workspace and workplace design, assessment tools and administrative awareness [12].

The awareness of implication of ergonomics can be measured by the extent of their beliefs on ergonomics effect to the workers such as the implication of high force towards workers [11, 13], repetitive motions [11, 14], workspace [11], and long term exposure [12, 13]. The ergonomics awareness also can be measured by looking at the suitability of jobs regarding the type of tasks according to standards suitable for ergonomics [10, 11, 15, 16].

Equipment specification suitable to workers, hand jigs and fixtures [11], workspace and workplace design is important to be evaluated as this can determine the ergonomics awareness technically [12]. Based on improvement awareness, the OSH practitioners need to determine the improvement methods, work study using time measurement to decide their capability of doing work and continuous improvement [14, 16].

Safety culture is a critical factor in implementation of safety and health and it is believed to give a positive impact to the companies [1, 3, 17–21] such as increase productivity and profit by reducing rejects, cost and reducing stress. It can be achieved through comfortable work environment, designed tools, man-machine interface and work method.

The purpose of inculcating a safety culture is to develop a nature of safe work consistently and guided by a well-defined set of core values that protect and promote the health and well-being of the individual and the environment [4]. Safety culture require a development of individual safety beliefs, attitudes and behaviors [22] and it must be initiated by OSH practitioners at the workplace.

The strength of safety culture can be measured by looking at some of the attributes such as commitment, leadership, communication, employee involvement, motivation and safety practice.

Commitment of top management to OSH is vital in all undertakings to reduce injuries, diseases, fatalities in order to improve efficiency, productivity and business performance [3, 19–21, 23]. The commitment by top management including OSH practitioners could be shown through the development of policy, approval of budget, time allocation to attend meeting, observation and direct advice on OSH to workers.

Leadership is one of the key success of safety culture and it can be demonstrated together with management commitment [24]. The activities does not have a great difference with commitment. This involves the top management commitment in providing resources, motivation, priorities and accountabilities [25], developing communication skill, listening, mentoring, facilitating and observational skill [23].

All can be achieved through suitable training for employees and top management in order to enhance the safety awareness and ergonomics awareness [26–28].

Motivation can influence behavior towards safety [1, 20, 24, 29]. Rewards such as financial or recognition reward can be a motivation to the workers. Employee involvement can be an approach to motivation. It will develop feelings of self-worth, belonging and values by involving them in training, consultation about PPE and job rotation [3, 19, 21, 24, 30]. Employee empowerment allows them the freedom of power to suggest and implement good practice at work place [3, 23].

Safety practice is about how to manage safety in a systematic way [3, 10, 18]. It covers and emphasizes the formalization of safety policy, formulation of safety procedure, describing how safety problems are identified, investigated, assessed, controlled and implemented [23].

3 Problem Identification

The function of managing safety is usually assigned to a person in charge (Sect. 29 [10]) namely Safety and Health Officer (SHO). In Malaysia, such people may also be designated post such as Safety and Health and Environment Officer (SHE), Health, Safety, Environment and Security Officer (SHES), safety engineer and the like. For the research purpose, the terminology of Safety and Health Practitioner (OSH practitioner) will be used in a broader context. They are well-trained to manage the risk, and proactively intervening in unsafe situations [26].

The responsibility of OSH practitioners is very high as the employer give the authority to OSH practitioners to ensure the highest safety and health standards at the workplace and he/she constantly interacts the employer regarding acts and regulations (regulation 18, safety and health regulation under [10]). They are also representatives of the companies to initiate any activities and steps to be taken including to advise the employer in any matter related to safety and health.

However, the role of OSHA regarding ergonomics has been ill-defined. In Malaysia, there is no specific act, regulations or guideline available to explain ergonomics implementation in general, unlike safety issues [31]. Ergonomics is important at least in theory but its actual awareness among Malaysian OSH practitioners has not been investigated. Human factors or ergonomics is believed to play a fundamental role in organization health and safety performance and this indirectly is also associated with safety culture.

The objective of the study is to investigate the extent of ergonomics awareness and its influence in inculcating safety culture amongst OSH practitioners. Ergonomics awareness is measured by their attitude in determining ergonomics importance at workplace. Basic knowledge is not studied in this paper as it is well informed that their basic knowledge on ergonomics awareness is adequate among the OSH practitioners.

4 Methodology

Some researchers in psychology such as [32, 33] suggested that attitudes included three components: cognitive, affective and conative (behavioral). Chang and Liao [34] summarized the three components whereby the cognitive represents the beliefs or idea associated with a particular subject. The affective component is the individual's evaluation of the object and emotion associated with the object. The conative illustrates the action or intention toward action directed at the object. Shafel and Shafel [35] concluded that attitude also affects behavioural intentions, which represent 'a plan of action that is arrived at through conscious, deliberately processing'. Davidson et al. [36] found that 'intention was better predictors of behavior'. Chang and Liao [34] called it as behavior intention and used this methodology in their research to measure attitude of their case study object in the aviation field. For this paper, the authors developed the question on the basis of cognitive components, representing the beliefs of respondents. It is used to measure attitudes of OSH practitioners on the importance of ergonomics on some issues.

A seven-point likert scale was employed to the both questions of ergonomics importance at workplace and safety culture to respond to those items. (1 = not relevant, 2 = not important at all, to 7 = critical).

4.1 Procedure of Collecting Data

250 mails were delivered to OSH practitioners in manufacturing industries and 108 completed replied were received. This number of response is considered adequate as the trend is similar in other parts of the world, even in developed nations [37, 38].

4.2 Demographic Data

SHO were asked on their position, level of education, year of work experience gained in company or other companies, year of work experience as OSH practitioners and training obtained for past three years. Respondents in companies include those in electrical and electronic (27.8%), chemical or apart (15.7%), metal, machines and equipment (13%), rubber or plastic based (12%), automotive and accessories (7.4%), wooden product including furniture (4.6%), printing and publishing (2.8%), paper and paper based (0.9%), textile and leather (0.9%) and others (food manufacturing, medical products)(14.8%). Education levels were in the following categories: SPM (11.1%), Diploma (28.7%), Degree (47.1%) and Post Graduate degree (13%). Most of them were called Safety and Health Officer (SHO) (50.9%), Safety, Health and Environment Officer (SHE) (38.9%), Health and Safety, Environment and Security Officer (SHES) (4.6%), engineer (2.8%), and others (safety and health executive,

safety and environment affairs manager, and ergonomist) (2.8%). Based on their work experiences in company/ companies, most of them have 16–25 year experience (41.7%) and more than 25 years (21.3%). The others were 0–5 year (19.4%) and 6–15 years (17.6%).

4.3 Content Validity

In this study, all the measurement items were developed and constructed based on literature review and validated by relevant representatives from NIOSH, academicians, DOSH and companies. This is important to determine that the items represent the domain of the construct.

4.4 Exploratory Factor Analysis

EFA is used to identify how many latent variables underlie the complete set of items and reducing those items to a smaller, more manageable set of underlying factors [34]. The presence of meaningful patterns among 29 ergonomics beliefs on importance at the workplace items and simplified the importance contained in a small set of factors or dimensions. The EFA can be used when researchers have measurements on collection of variables and would like to have some idea about what construct might be used to explain the inter-correlation among these variables [39].

The questions of ergonomics importance at workplace were verified and modified from the work done as mentioned in conceptual background.

EFA was done on the 29 items of ergonomics. The Overall-Keiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis. After deleting items which has low factor loading and reliability, 20 items were identified to be appropriate for further analysis. The KMO for ergonomics importance was 0.92 (superb according to Field, 2000) with factor loading values ranging from 0.58 to 0.82. The Bartlett Test of sphericity reached statistical significance with $\chi^2(108) = 1644.21$, $p < 0.0001$ indicating that the correlation between the items were sufficiently large for Principle Component Analysis (PCA). The three factors solution explained a total of 57.35% of the variance, with factor 1 contributing 54.58%, factor 2 contributing 8.06% and factor 3 contributing 6.66%. The reliability analysis, measured by Cronbach alpha α values ranged from 0.80 to 0.93 and were considered as having high internal consistency for three-factor safety culture. Factor analysis, percent of variance and Cronbach alpha value can be seen in Table 1. These 20 items with three new factors namely as: (1) ‘implication of and need for improvement’ (10 items), (2) ‘fitting the jobs to workers’ (7 items) and (3) ‘basic ergonomics considerations’ (3 items).

Safety culture variables were derived and modified from previous work done by [3, 17, 19, 40] and some literature relating to the field of safety culture and safety management [1, 17, 21, 24, 27, 30]. Altogether 22 items were developed and analysed

Table 1 Factor analysis of ergonomics importance at workplace

Factor and items	Factor loading	% of variance	Cronbach alpha (α)
Implication of and need for improvement		54.58	0.926
1 ..high force against time (example: involving high force within 30 min continuously or more than 2 h within 8 work hours-lifting goods at warehouses)	0.81		
2 .. repetitive movement (example: involving repetitive job with 2 times in a minute at one time,—assembly work at workplace , using spanner repetitively as a tool in long duration)	0.78		
3 .. improvements based on ergonomics analysis (example: RULA, REBA, OCRA)	0.77		
4 .. effect of work on workers (example: duration, shift)	0.76		
5 .. work study considering for allowances in time measurement for a task (example: allowance for emergency, going to toilet, doing other works, administrative work)	0.72		
6 .. continuous improvements (example: always include ergonomics issue in safety meeting agenda)	0.67		
7 .. suitable number of workers for each production line (example: give ergonomics consideration in terms of workers psychological effect)	0.67		
8 .. the importance of work space provision (example: location of control switch and suitable workspace and workplace for the workers who has short hand or leg)	0.66		
9 .. the importance of improving long term exposure to unergonomics workplace design (example: protection from hard surface through suitable foot wear and anti fatigue mats)	0.57		
Fitting the job to workers		8.06	0.915
1 .. according to age, suitability or health condition	0.77		
2 ..improvement based on common sense.	0.78		
3 ..improvement based on standards (example: guideline by DOSH, ISO or ILO references)	0.72		
4 .. specification of equipment suitable to workers (adjustable equipment; size of chair, width of seat)	0.69		
5 .. checking the suitability of equipment for a given task (example: machine that use one hand or two hand operation)	0.66		
6 .. hand tools to handle work piece such as jigs and fixtures.	0.63		
7 .. the guidelines for ergonomically designed seating and furniture	0.59		
Basic ergonomics considerations		6.65	0.804
1 ..anthropometric data in purchasing equipment (example: purchasing chair for office work)	0.82		
2 .. anthropometric data in workspace design (example: work piece is arranged according to importance or the primer, secunder and tertier access zone, workers can move comfort in workspace)	0.81		
3 .. anthropometric data in layout design (example: seating work that involving sequences, need the work layout to be arranged in semi-circle towards worker)	0.60		

Total variance 65.636%, KMO = 0.919, Bartlett test $\chi^2 = 1644.205$, df = 210, significance level (p) = 0.0001

using SPSS. The KMO for safety culture was 0.92. The Bartlett Test of sphericity with $\chi^2(108) = 1447.59$, $p < 0.0001$. The three factors solution explained a total of 57.35% of the variance, with factor 1 contributing 57.352%, factor 2 contributing 8.24% and factor 3 contributing 6.11%. The reliability analysis, measured by cronbach alpha (α) values ranged from 0.92 to 0.94 and were considered as having internal consistency for three—factor safety culture. Factor analysis, percent of variance and Cronbach alpha value can be seen in Table 2. After EFA, the items become 17 items with the three new factors namely as: (1) Commitment and leadership (7 items), (2) Motivation (6 items), and (3) Safety Management System Practice (4 items).

5 Discussions

EFA is used to identify suitable factors or dimensions for the beliefs on ergonomics importance at the workplace towards safety culture. Based on the final results on empirical study, three crucial factors relating to awareness of ergonomics importance at workplace were identified: (1) Implication of and Need for Improvement, (2) Fitting The Job To Workers and (3) Basic Ergonomics Considerations.

5.1 *Ergonomics Awareness Factor*

Implication of and Need for Improvement is important as it needs employer to be aware on implications of not being aware of the ergonomics risk and mentioned briefly in regulation 18 (Duties of Safety and Health Officers Regulation 1997) [10] and Regulation 11 (Functions of Safety and Health Committee) under OSHA 1994 [10, 13] to inspect any machinery, plant, equipment, or any manual work that may cause injuries and to review the effectiveness of safety and health programs.

Fitting the job to the workers or other word is to 'fit the job to the man' and is the guiding philosophy of ergonomics because it is about human engineering and workspace design relating to the design tasks to suit the characteristics of workers. It is the underlying assumptions that can be specified around which the job can be designed for any jobs [11].

Basic ergonomics considerations are some issues of awareness that emphasized the importance of ergonomics related to the physical or namely as anthropometric data [11, 15, 41] such as consideration of equipment design suited to the workers while purchasing equipment mentioned in 15 (2)(b) OSHA 1994 [10], layout design and workspace design under regulation 20 and regulation 24 (Safety, Health and Welfare Regulation 1970) under FMA 1967 [31].

Table 2 Factor analysis and reliability analysis on safety culture

Factor and items	Factor loading	% of variance	Cronbach alpha (α)
Commitment and leadership		57.35	0.91
1 Developing teamwork spirit	0.79		
2 Top management approved the use of new technology for generating an ergonomics environment	0.77		
3 New employee is instilled with the importance of ergonomics in the workplace	0.71		
4 Give suitable rewards to workers who give suggestions on safety and health improvement	0.71		
5 Ensure employees are both involved and empowered	0.66		
6 Analysis and ergonomics improvements assisted by consultation	0.64		
7 Give enough knowledge (training) to the safety and health practitioner in the organization.	0.63		
Motivation		8.24	0.92
1 Meeting periodically held between managers and workers to take decisions affecting organization of work	0.86		
2 Employees view safety and health (including ergonomics) as the natural, normal and acceptable way of doing things	0.77		
3 Top management provide financial support for ergonomics issue	0.75		
4 Incentive offered to workers to suggest improvement in working conditions	0.71		
5 All organization level changed to ergonomics behavior	0.69		
6 Incentive offered to workers to put in practice and procedures of action	0.58		
Safety management system practice		6.11	0.87
1 Organization levels comment on each other on safety and health issue to identify corrective action	0.83		
2 Safety policy contains commitment to continuous improvement, attempting to improve objective already achieved	0.80		
3 Safety and health policy (including ergonomics) is co-ordinated with HR policies	0.75		
4 Standards of action or work procedures elaborated on basis of risk evaluation	0.69		

Total variance = 71.70, KMO = 0.915, *Bartlett Test* $\chi^2 = 1447.59$, df = 136, significance level (p) = 0.0001

5.2 Safety Culture Factor

For the safety culture construct, the elements identified in this chapter included: (1) commitment and leadership, (2) motivation and (3) safety management system practice.

Commitment and leadership covers employee involvement [3, 19] and commitment by top management [3, 19–21, 30], leadership [26–28], subsequently would give an impact to employee empowerment [21]. It is also covered attending OSH committee chair, supporting for the development and implementation of safety programs by physical and spiritual, approving financial and technology used [42] in order to get the employee to be involved and empowered in safety activities [29, 34, 42]. Leadership aspect includes the way top management control the safe operating procedure (SOP), show the safe way to do task, listen and communicate actively with members of team.

Motivation part is emphasized by job satisfaction [6, 28] by encouragement of practicing what they obtained in training [29]. Safety culture can be successful if top management appreciate the employees and give incentives for the safe behavior [18, 24, 29], which in turns the workers will feel free to discuss, openly, without barrier on safety programs, risk or any matter related to safety and health.

Safety management system is one of the factor that can develop safety culture [1, 17–20, 24, 27] which is measured by policy, procedures, financial budget, continuous improvement [17, 19, 28].

However, it is possible to confirm these construct model of Ergonomics Awareness to Safety Culture by Confirmatory Factor Analysis (CFA). AMOS will be used to confirm the Exploratory Factor Analysis (EFA).

6 Conclusions

The empirical study has identified three principal elements on ergonomics awareness that will have significant impact on safety culture measured by using three measurement variables. The finding of this study has contributed theoretically to a growing body of knowledge on ergonomics awareness amongst OSH practitioners in terms of their beliefs on ergonomics importance towards safety culture. This paper suggests the constructs of ergonomics awareness to safety culture and evaluated by EFA. To some extent, further work will be needed to confirm the theoretical model through Confirmatory Factor Analysis (CFA). This paper is a revised and extended version of a paper that was presented at WCE 2012 [31].

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