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Validation of a Research Instrument for Safety Leadership and Safety Knowledge-Attitude-Behaviour (KAB) for Malaysia Manufacturing Set-Up

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ABSTRACT

This article provides empirical evidence on the validity of a questionnaire designed to assess safety leadership and safety knowledge-attitude-behavior (Safety KAB) within Malaysia's manufacturers, which fall under small and medium (S & M) entrepreneurship. The questionnaire's items were adapted from earlier research conducted in other study contexts. First, the modified fuzzy delphi method (FDM) was applied to obtain experts' consensus regarding the content validity of all items. With some modifications to suit Malaysia's SME manufacturing setting, the 5-point Likert-scale questionnaire consisting of 42 items for measuring safety leadership and safety KAB were finalized. Subsequently, it was distributed to 100 production operators from the manufacturing S& M enterprises in the Northern Corridor Economic Region (NCER) of Malaysia for pilot testing. 95 respondents had answered. They returned the questionnaires, and 89 were best to be chosen for further procedures. The Cronbach's alpha values were more than 0.90 for all items representing those variables, indicating that the questionnaire possessed high reliability and internal consistency. Subsequently, exploratory factor analysis (EFA) employing principal component analysis (PCA) extraction and varimax rotation was performed to determine the construct validity. According to the PCA results, each item was retained as all the factor loadings were above the decided cut-off value, which is 0.65. Henceforth, the questionnaire is considered valid and reliable to be used by future researchers.

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1. Introduction

An occupational accident has become the central issue in Malaysia (Ayob et al., 2018; Nasidin et al., 2020). Manufacturing is declared as the sector with the highest number of accidents every year (Aziz et al., 2015; Zulkifly et al., 2020), and most of them are categorized as Small and Medium (S & M) Enterprises (Nor Azma et al., 2016; Zulkifly et al., 2021). Safety behavior has been a significant contributor to industrial accidents (Bowonder, 1987; Gyekye, 2010; Heinrich, 1941; Zulkifly et al., 2017). Thus, fostering safety behavior could be the best way for elevating workplace safety levels within SMEs in Malaysia and decrease accidents (Khoo et al., 2011; Subramaniam et al., 2016; Zulkifly et al., 2017). In addition, safety leadership has a significant effect on workers' safety behavior and companies' safety performance (Chua & Wahab, 2017; C. S. Lu & Yang, 2010; Wu et al., 2008). Moreover, safety leadership is regarded as the most effective strategy for reducing industrial injuries (Beus et al., 2016).

In considering the limitations and constraints, especially in terms of financial, knowledge, and workforces (Hassan et al., 2019; Subramaniam et al., 2016; Zulkifly et al., 2017, 2018), safety leadership by the management, specifically the owner-managers as well as supervisors should appear as the best approach to reduce accidents through fostering workers' safety behavior. Moreover, Malaysian SMEs have supervisors who support their subordinates in safety matters to ensure effective occupational safety and health (OSH) management (Khoo et al., 2011).

On the other hand, previous researchers also found safety-related knowledge to impact safety behavior (Neal et al., 2000; Neal & Griffin, 2006; Vinodkumar & Bhasi, 2010). Besides, scholars also determined that safety attitude significantly influences safety behavior (M. S. Abdullah et al., 2016; Kao et al., 2019; Sugumaran et al., 2017). According to Bandura (1989), personal knowledge and skills could influence them to engage in a particular behavior. The central idea behind the social cognitive perspective is that individuals can self-regulate their thoughts, motivation, and behavior; and subsequently influence others to engage with similar actions (Azim et al., 2017).

In realizing this fact, this paper aims to establish a reliable and valid research instrument purposely developed to measure safety leadership variable and safety KAB among workers in manufacturing S & M enterprises.

2. Literature Review

2.1. Research Variables

Safety behavior is defined as action taken by the self to avoid accidents while working (Khdair et al., 2011). The behaviors are including following safety procedures and wearing personnel protective equipment, or participating in safety-related programs conducted by the employers (C.-S. Lu & Yang, 2010; Vinodkumar & Bhasi, 2010).

Safety leadership refers to the capability of leaders in influencing workers to achieve organizational safety goals(Cooper, 2015). Previous scholars utilized different dimensions to reflect the safety leadership of superiors in determining safety behavior or safety performance. For example, Lu and Yang (2010) measured safety leadership using safety policy, safety concern, and safety motivation in a study conducted among container terminal workers in Taiwan. The dimensions were adapted by Zulkifly et al. (2017), who performed a study determining the effect of safety leadership on safety behavior among S & M workers in Malaysia. Similarly, the dimensions were also tested among Malaysian technic and vocational students (Karthega, 2018). On the other hand, safety caring, safety controlling, and safety coaching were the other dimensions of safety leadership utilized by previous researchers (Wu, 2008; Wu et al., 2008). The dimensions were tested in Malaysia by (K. H. Abdullah & Aziz, 2020; Chua & Wahab, 2017) conducted studies towards Malaysia's laboratory students and manufacturing workers. Besides these dimensions, Du and Sun (2012) conducted a study in China and measured safety leadership by 3 dimensions: active management, safety motivation, and safety monitor. Moreover, Zulkifly et al. (2021) recently have tested the dimensions of safety leadership, namely safety coaching, safety concern, and safety monitoring, on their effect on safety KAB in Malaysia's manufacturing firms. The results found significant direct effects of the higher-order models of safety leadership on safety KAB within manufacturing S & M.

In terms of definition, Kulkarni et al. (2016) concluded that safety knowledge is the capability of workers to recognize the risks associated with theirs work and their ability to follow safe working procedures. While, Safety attitude refers to the workers' positive or negative tendency to act or behave towards a safety goal and procedures set by their companies (Kao et al., 2019; Sawhney & Cigularov, 2019).

2.2. The significant of the Research

This research is conducted to test the reliability and validity of a developed instrument measuring safety leadership and safety KAB. The instrument is proposed to be used on Malaysia's S & M (manufacturing) to measure the impacts of supervisor safety leadership and safety KAB. S & M companies are not similar to larger firms whereby the former own several limitations, especially in terms of resources and financial (Kee et al., 2019; Mat Saat et al., 2016; Zulkifly et al., 2017). Therefore, managing occupational safety and health in S & M companies need to be more specific and tailored to their circumstances (Legg et al., 2015). Safety leadership is proposed to be the most appropriate approach in succeeding safety performance among S & M Manufacturing in Malaysia (Zulkifly et al., 2017).

Thus, establishing a valid and reliable research instrument by this research is essential in providing an alternative measurement for future researchers to research safety leadership. The results of this study could serve as empirical evidence for researchers in occupational safety and health area.

2.3. The Validity of a Research Instrument

For instrument validity, the *Fuzzy Delphi* method modified was applied to determine the expert consensus on its content validity (Adler & Ziglio, 1986;Ranjan et al., 2020). In achieving the experts' consensus, the analysis of FDM must fulfill three conditions(Mohd Jamil et al., 2017; Mohd Ridhuan et al., 2015) : i) Threshold value d is at least 0.2 ($d \leq 0.2$), ii) Percentage of expert's consensus is more excellent than 75%, and iii) Fuzzy Score, A must be at least 0.5 ($A \geq 0.5$).

Furthermore, Principal Component Analysis is the most popular method (Julie Pallant, 2010; Tabachnick & Fidell, 2014). According to Tabachnick and Fidell (2014), First, Kaiser-Meyer-Olkin's (KMO) value must be at least 0.6 for sampling adequacy, with the support of Bartlett's Test of Sphericity need to be significant at $\rho < 0.05$. Furthermore, it is recommended that the accepted factor loadings for each item are 0.30 to 0.40. However, loading of more than 0.50 is preferred (Hair et al., 2010).

3. Methods

The items in the questionnaire were constructed based on the literature review, with most of the items adapted from questionnaires used in previous related research. Additionally, the questionnaire applies interval scales (Likert) from 1: "Strongly Disagree" to 5: "Strongly Agree."

Subsequently, the questionnaire needs to undergo the validity as well as the reliability test. For this research, a modified Fuzzy Delphi Technique – FDM (Adler & Ziglio, 1986; Mohd Ridhuan et al., 2015) was applied to determine the content validity. For FDM, 15 panels of experts were appointed based on previous research recommendations stating that the number of 10-15 panels is appropriate (Noh et al., 2019; Ranjan et al., 2020), Whereas the principal component analysis (PCA) was performed to determine the construct validity (J Pallant, 2007). In addition, the scale's reliability was measured using Cronbach's alpha values. (Sekaran & Bougie, 2013; Zikmund et al., 2010)

3.1. Adaption of Items for Safety Leadership

This research adapted all items were adapted from previous researches. A focus group consisted of five experts in the OSH area to finalize the items adaption, including modifying sentences to suit the research context. In this research, safety leadership was reflected by three dimensions, namely safety coaching, safety concern, and safety monitoring. Then, the items reflecting these dimensions were adapted from (Wu, 2008). The items were also tested in Malaysian manufacturing settings (Chua & Wahab, 2017). By comparing the items in both types of research, this paper adapted and modified them to suit the study context. Thus, the items, which the experts have endorsed were ready to be tested for their reliability and validity. Table 1 summarizes the information of the items. There are 5 finalized items for safety coaching and safety concerns, plus 6 finalized items for safety monitoring, representing safety leadership. The experts have decided to drop one item each for safety coaching and safety monitoring due to redundancy and reversed-item, respectively.

Table 1
Items for Safety Leadership

Variables	Dimensions	No of Items	Coding	Sources
Safety Leadership	Safety Coaching	5	Ch1* Ch2 Ch3 Ch4 Ch5 Ch6	(Chua & Wahab, 2017; Wu, 2008)
	Safety Concern	5	Cn1 Cn2 Cn3 Cn4 Cn5	
	Safety Monitoring	6	Mn1 Mn2 Mn3 Mn4 Mn5 Mn6 Mn7*	

3.2. Adaption of Items for Safety KAB

Safety knowledge measuring items (five items) were adapted from previous research (Vinodkumar & Bhasi, 2010). On the one hand, suitable instrumentation measuring safety attitude is limited within the SME context. Several previous types of research used a safety attitude questionnaire (SAQ) to determine safety attitude in the healthcare service sector (Gabrani et al., 2015; Sexton et al., 2006; Smits et al., 2017). On the other hand, Kao et al.(2019) used a 3-items designed by Henning et al. (2009)to examine construction worker safety attitudes. Besides, Sawhney and Cigularov (2019) examined the role of attitudes, norms, and perceived control over TPB-based safety behaviors as mediators in the relationship between safety-specific leader behaviors and safety motivation. Four items from the research measuring safety attitudes were used in this research as the experts agreed on the appropriateness of the context.

Table 2
Items for Safety KAB

Dimensions	No of Items	Item Coding	Sources
Safety Knowledge	5	K1 K2 K3 K4 K5	(Vinodkumar & Bhasi, 2010)
Safety Attitude	4	A1 A2 A3 A4	(Sawhney, 2016)
Safety Behavior	7	1 2 3 4 5 6 7	‹ao et al., 2019)

For safety behavior, items were adapted from and (Kao et al., 2019). With some modifications to suit, Table 2 summarized the items for safety KAB for this research.

3.3. Analysis of Content Validity

Contents validity is the degree to which the instrument and scores derived from it represent all conceivable questions about the content or skill (Creswell & Creswell, 2017). The content validity of this research is determined by conducting a critical review of the prior literature and Malaysian OSH law, including the master plan. According to Hsu et al. (2010), the most recent method for seeking expert opinion is using the Fuzzy Delphi Method (*FDM*), a technique adapted from the traditional Delphi method that is widely used to obtain expert approval. Furthermore, *FDM* is chosen in this study to generate a resolution from experts without sacrificing their initial view and offering an accurate response to the concerns (Noh et al., 2013). The criteria for qualified experts include OSH-related expertise, field authority, and ten years of experience. In research using the FDM, The suggested number of experts in the analysis is between 10 and 50 (Hsu et al., 2010). However, a scholar such as Adler and Ziglio (1996) and Manakandan et al. (2017) stated that 10 to 15 persons are sufficient for experts from a homogenous area. Several previous types of research have applied FDM for questionnaire validity (Hidayatul Fariha et al., 2019; Mokhtar & Yasin, 2018; Morales et al., 2018; Ranjan et al., 2020).

The panelists for this research comprise 15 OSH experts from industries, DOSH, and universities, having a minimum of ten years of experience in the specialized field of OSH (Skulmoski & Hartman, 2007). Subsequently, the items of the questionnaire had been presented to the experts, and the experts were also enquired to evaluate all items based on 7-point Likert-Scale (1 = Extremely Disagree, 2= Strongly Disagree, 3=Disagree,4= Neither Disagree nor Agree,5=Agree, 6= Strongly Agree, 7= Extremely Agree).

Subsequently, *FDM* is embarked, and the results are summarized in Table 3-7.

Table 3
FDM Results for Safety Coaching

No.	Triangular Fuzzy Numbers Requirement		Defuzzification Process Requirement				Expert Consensus
	Threshold value	Expert Group Consensus Percentage	m1	m2	m3	Fuzzy Score (A)	
1	0.094	93.3%	0.793	0.940	0.993	0.909	Accepted*
2	0.089	93.3%	0.820	0.953	0.993	0.922	Accepted*
3	0.116	93.3%	0.807	0.940	0.980	0.909	Accepted*
4	0.093	93.33%	0.807	0.947	0.993	0.916	Accepted*
5	0.112	86.67%	0.793	0.933	0.987	0.904	Accepted*

* d <2, expert consensus exceeding 75%, and A >0.5

Table 4
FDM Results for Safety Concern

No	Triangular Fuzzy Numbers Requirement		Defuzzification Process Requirement				Expert Consensus
	Threshold value	Expert Group Consensus Percentage	m1	m2	m3	Fuzzy Score (A)	
1	0.083	93.3%	0.833	0.960	0.993	0.929	Accepted*
2	0.089	93.3%	0.820	0.953	0.993	0.922	Accepted*
3	0.068	100.0%	0.833	0.967	1.000	0.933	Accepted*
4	0.107	86.67%	0.820	0.947	0.987	0.918	Accepted*
5	0.131	86.67%	0.820	0.940	0.973	0.911	Accepted*

* d <2, expert consensus exceeding 75%, and A >0.5

Table 5
FDM Results for Safety Monitoring

No	Triangular Fuzzy Numbers Requirement		Defuzzification Process Requirement				Expert Consensus
	Threshold value	**Expert Group Consensus Percentage**	**m1**	**m2**	**m3**	***Fuzzy Score (A)***	
1	0.073	100.0%	0.820	0.960	1.000	0.927	Accepted*
2	0.060	100.0%	0.847	0.973	1.000	0.940	Accepted*
3	0.112	86.7%	0.793	0.933	0.987	0.904	Accepted*
4	0.049	100.00%	0.860	0.980	1.000	0.947	Accepted*
5	0.089	93.33%	0.820	0.953	0.993	0.922	Accepted*
6	0.076	100.00%	0.807	0.953	1.000	0.920	Accepted*

* d <2, expert consensus exceeding 75%, and A >0.5

Table 6
FDM Results for Safety Monitoring

No	Triangular Fuzzy Numbers Requirement		Defuzzification Process Requirement				Expert Consensus
	Threshold value	**Expert Group Consensus Percentage**	**m1**	**m2**	**m3**	***Fuzzy Score (A)***	
1	0.049	100.0%	0.860	0.980	1.000	0.947	Accepted*
2	0.076	100.0%	0.793	0.947	1.000	0.913	Accepted*
3	0.111	86.7%	0.807	0.940	0.987	0.911	Accepted*
4	0.073	100.00%	0.820	0.960	1.000	0.927	Accepted*
5	0.060	100.00%	0.847	0.973	1.000	0.940	Accepted*

* d <2, expert consensus exceeding 75%, and A >0.5

Table 7
FDM Results for Safety Attitude

No	Triangular Fuzzy Numbers Requirement		Defuzzification Process Requirement				Expert Consensus
	Threshold value	**Expert Group Consensus Percentage**	**m1**	**m2**	**m3**	***Fuzzy Score (A)***	
1	0.089	93.3%	0.820	0.953	0.993	0.922	Accepted*
2	0.068	100.0%	0.833	0.967	1.000	0.933	Accepted*
3	0.068	100.0%	0.833	0.967	1.000	0.933	Accepted*
4	0.073	100.00%	0.820	0.960	1.000	0.927	Accepted*

* d <2 , expert consensus exceeding 75%, and A >0.5

Table 8
FDM Results for Safety Behavior

No	Triangular Fuzzy Numbers Requirement		Defuzzification Process Requirement				Expert Consensus
	Threshold value	**Expert Group Consensus Percentage**	**m1**	**m2**	**m3**	***Fuzzy Score (A)***	
1	0.035	100.0%	0.873	0.987	1.000	0.953	Accepted*
2	0.112	86.7%	0.793	0.933	0.987	0.904	Accepted*
3	0.094	93.3%	0.793	0.940	0.993	0.909	Accepted*
4	0.111	100.00%	0.780	0.927	0.987	0.898	Accepted*
5	0.089	93.33%	0.820	0.953	0.993	0.922	Accepted*
6	0.111	100.0%	0.780	0.927	0.987	0.898	Accepted*
7	0.035	100.0%	0.873	0.987	1.000	0.953	Accepted*

* d <2 , expert consensus exceeding 75%, and A >0.5

3.5. Reliability and Construct Validity

Subsequently, the questionnaire' items involved need to undergo construct validity and the reliability test (Chua, 2012; Sekaran & Bougie, 2016). Cronbach's Alpha is utilized to determine the reliability of instruments in this study. Table 9 summarizes Cronbach's Alpha values interpreted following Zikmund et al. (2010).

Table 9
Cronbach's Alpha

Cronbach's Alpha	Interpretation for Reliability
"0.80 - 0.95"	Outstanding
"0.70 – 0.80"	Good
"0.60 – 0.70"	Fair
"Below 0.60"	Poor

Factor analysis is a methodology for verifying the precision of the items used in measuring a construct (Hair et al., 2010). Hair et al. (2010) suggested utilizing a sample size of 100 or more to perform factor analysis. However, more than 50 observations are still sufficient for factor analysis. Hair et al. (2010) also suggested conducting factor analysis with 5 observations per variable. The number of respondents in this research was 91, which is considered acceptable.

Furthermore, Hair et al. (2010) suggested that factor loadings in the range of 0.30 to 0.40 be deemed acceptable. However, values greater than 0.50 are preferred (very significant). Because there were 91 (ninety-one) respondents in this study, the cut-off point of 0.65 was used as the factor loading value, as Hair et al. (2010) proposed. It means that any value less than 0.65 is discarded.

A pilot test was conducted to assess the reliability and construct validity. A total of 100 questionnaire sets were distributed to operators from manufacturing companies in the northern region of Malaysia to be answered. From the total of 100 pieces distributed, 90 were returned, and one was discarded due to incompletion. The demographic profiles of the respondents are summarized in Table 10.

Table 10
Demographic Profiles of Respondents

		N	%
Gender	Male	51	57.3
	Female	38	42.7
Marital Status	Single	37	41.6
	Married	46	51.7
	Divorced/Widowed	6	6.7
Education Level	LCE/SRP/PMR	3	3.4
	MCE/SPM/SPMV	21	23.6
	HSC/STPM/Cert.	8	9.0
	Diploma/Adv.Dip.	40	44.9
	Degree & Above	17	19.1
Age	20-30 years old	38	42.7
	31-40 years old	40	44.9
	41 – 50 years old	8	9.0
	51 years old and above	3	3.4

Subsequently, the reliability test was conducted on the data to determine Cronbach's alpha value. The results showed that all items measuring all variables hold Cronbach's alpha values within the range of 0.931 to 0.956, which indicated good reliability (Zikmund et al., 2010). Table 3.3 details the reliability test's results.

Table 11
Cronbach's Alpha

Variables	Cronbach's Alpha	Interpretation of Reliability
"Safety Coaching"	0.931	Outstanding
"Safety Concern"	0.942	Outstanding
"Safety Monitoring"	0.944	Outstanding
"Safety Knowledge"	0.950	Outstanding
"Safety Attitude"	0.942	Outstanding
"Safety Behavior"	0.956	Outstanding

Following that, factor analysis was performed on the data from the pilot test. First, the Kaiser-Meyer-Olkin (KMO) value must be greater than the minimum required value of 0.60, as Tabachnick and Fidell (2014) proposed to show sample adequacy. Subsequently, Bartlett's Test of Sphericity must be statistically significant at $\rho < 0.05$, evaluating the correlation matrix's factorability. Furthermore, Hair et al.(2010) stated that factor loadings should be 0.3 to 0.4. However, loadings greater than 0.50 are preferred (very significant). As requested by the test subjects, the cut-off point was set at 0.65 as the value of the factor loadings (Hair et al., 2010).

After performing the factor analysis, the KMO value for safety coaching is 0.863, above the cut-off value of 0.65; Bartlett's Test of Sphericity was significant at $\rho < 0.05$. Only one component had achieved the eigenvalue of more than 1, with the percentage of variance being 78.421%. The factor loadings for all items is more than 0.65. The factor loading is summarised in Table 12.

Table 12
Safety Coaching (Factor Loading)

	Component 1
Ch1	.827
Ch2	.883
Ch3	.924
Ch4	.870
Ch5	.920

Subsequently, for safety concerns, the KMO value is 0.891, with Bartlett's Test of Sphericity was significant at $\rho < 0.05$. Only one component is extracted with the eigenvalue of 4.066 (more than 1), with the percentage of variance is 81.327%. Furthermore, the factor loadings are more than 0.65. The result is summarized in Table 13.

Table 13
Safety Concern

	Component 1
Cn1	.792
Cn2	.890
Cn3	.931
Cn4	.948
Cn5	.938

Furthermore, the KMO value is 0.880 for safety monitoring with Bartlett's Test of Sphericity reached statistical significance, $\rho < 0.05$. Only one component is extracted with the eigenvalue of 4.701 (more than 1), with the percentage of variance is 78.358%. Additionally, the factor loadings are more than 0.65. The result is summarized in Table 14.

Table 14
Safety Monitoring

	Component 1
Mn1	.841
Mn2	.921
Mn3	.844
Mn4	.867
Mn5	.926
Mn6	.908

Furthermore, the KMO value for safety knowledge is 0.886 for Bartlett's Test of Sphericity reached statistical significance, $\rho < 0.05$. Only one component is extracted with the eigenvalue of 4.163 (more than 1), with the percentage of variance is 83.252%. Also, the factor loadings are more than 0.65. The result is summarized in Table 15.

Table 15
Safety Knowledge

	Component 1
K1	.888
K2	.906
K3	.931
K4	.931
K5	.906

Subsequently, the KMO value for safety attitude is 0.802 for Bartlett's Test of Sphericity reached statistical significance, $\rho < 0.05$. Only one component is extracted with the eigenvalue of 3.409 (more than 1), with the percentage of variance is 85.221%. Furthermore, the factor loadings are more than 0.65. The result is summarized in Table 16.

Table 16
Safety Attitude

	Component 1
A1	.948
A2	.934
A3	.922
A4	.888

Furthermore, the KMO value for safety behavior is 0.909 for Bartlett's Test of Sphericity reached statistical significance, $\rho < 0.05$. Only one component is extracted with the eigenvalue of 7.654 (more than 1), with the percentage of variance is 69.586%. Subsequently, the factor loadings for are more than 0.65. The result is summarized in Table 17.

Table 17
Safety Behavior

	Component 1
B1	.886
B2	.841
B3	.886
B4	.814
B5	.830
B6	.829
B7	.859

4. CONCLUSION

This article aimed to evaluate the validity of a research instrument used to assess safety leadership and safety KAB in the S & M (manufacturing) study settings. According to the statistical analyses conducted, the research instrument has excellent reliability based on the obtained Cronbach's Alpha value. Moreover, each questionnaire's item has been maintained based on the factor analyses, as all factor-loadings exceed the set minimum value of 0.65.

Additionally, the KMO values for all variables are more than 0.50. Additionally, *Bartlett's* Test also satisfies the pre-requisite criteria.

Nonetheless, the questionnaire items were subjected to a systematic approach of content validation, namely FDM, by a qualified field expert. As a result, the questionnaire developed is deemed valid and reliable. Therefore, the established questionnaire is ready to be used by future researchers.

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