Comprehension-Based Ergonomic Redesign of Equipment Warning Signs in Philippines Manufacturing Industry

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Abstract

The research purpose is to assess the level of comprehension of the worker on equipment warning signs in the Philippines. To identify the factor(s) affecting the result of the comprehension score and propose an improved alternative design regarding ergonomic principles of warning sign design. A method of Analytical Hierarchy Process (AHP) employed in the selection of the most appropriate design. The result shows that more than half of the assessed warning signs fall below the standards set by the American National Standard Institute (ANSI), which leads to the proposal of alternative warning sign design. The study conducts a controlled survey to collect data from 90 respondents in the manufacturing industry. The data was analyzed by Structural Equation Modelling (SEM) using AMOS in SPSS Statistical software. The result shows a strong influence of Education and Work Experience on warning sign comprehension. The ergonomic principles show a significant impact on the improvement of comprehension level, which was confirmed using a 2-sample-t hypothesis test.

Keywords
AHP, SEM, warning sign, ergonomics, occupational safety

1. Introduction
Whenever accidents happen, the adequacy and comprehension of warning signs and labels are always a point of assessment in the manufacturing industry. In manufacturing, there are 2.78 million annuals occupational- related deaths in the world, which is a report by the International Labor Organization (ILO) new estimates (ILO, September 2017). The latest estimates total is 19% higher than the occupational-related deaths as compare to earlier ILO report in 2014.

A total of 380,500 yearly fatalities is accounted, for occupational safety accidents, and two-thirds of the world occupational accidents are in Asia, which is 253, 666 deaths yearly (Figure 1).

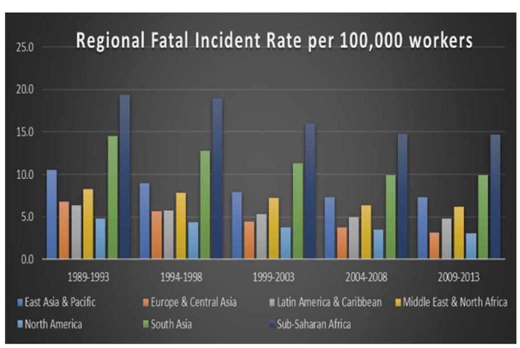

Figure 1. Regional Distribution of Fatal Injuries

The regional differences in fatality rates are at the highest across the East Asia and Pacific (Figure 2), and South Asian regions (The Global Epidemic of Occupational Injuries; Ujwal, Kharel, May 2017).

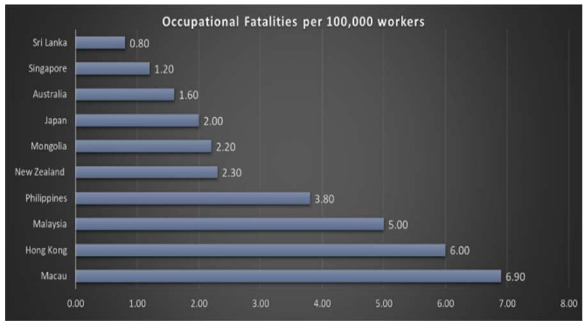

Figure 2. Regional Occupational Fatal Injuries

In Asia, Macau and Hong Kong are on top of the chart, which is belong to the Republic of China. In the third spot was Malaysia and was followed by the Philippines at 3.8. Currently, there is a total of 42 million employed Filipinos, and these statistics mean 1,632 occupational-related fatal injuries. Occupational related risk cannot be eliminated, as stated by Canadian Center for Occupational Health and Safety (CCOHS, February 2, 2017), but needs a continuous effort to mitigate the risk and lighten the impact of potential safety incidents. Several safety activities can be done in every workplace, like; safety awareness campaigns, training, safety meetings, emails, posters, and equipment warning signs and labels. All these can help reduce the risk of severe injury or death.

The success of all above mention safety activities depends on how well this safety information was roll-out to workers. It is also vital to evaluate the level of comprehension and effectiveness of warning signs and labels

The purpose of warning signs and labels is to convey important safety-related information to workers with an intent to develop a safe working attitude or behavior (Stazzon Shelly, July 2, 2019). And in the process, reduce occupational-related accidents occurrences. Symbolic signs have great appeal as a means of conveying, and they perform better than written warnings, especially with degraded viewing conditions (Ells and Dewar, 1979).

Safety warning signs standards implemented in Japan and Europe may not be as effective in other parts of the world like China and the Philippines (Whitfield, Geoffrey P., et al., November 2019). It may be due to some level of understanding and yet to be known factors inherent to those foreign countries.

This study conducts a controlled survey and data analysis using SEM by SPSS software. The result confirmation will then be applying a 2-sample-t hypothesis test.

2. Objectives

This study composes of three parts, first, to examine the comprehension level and assess the effectiveness of communicating the safety information with the use of standard equipment warning signs in Philippine manufacturing operation. Then second, it is to identify inherent factors directly affecting the comprehension of warning signs. And third, is to propose a warning sign for those with failed scores, to improve comprehension level. These standards that the manufacturing industry in the Philippines needs a systemic and direct evaluation. The study intends to identify gaps in comprehension of warning signs and to propose necessary actions.

3. Methods

A direct evaluation through the survey will be employed to assess whether workers can identify warning signs accurately and be able to measure comprehension level, identify significant factors affecting comprehension scores, and proposed alternative warning sign designs about ergonomic principles.
Data Source and Demographics

3.1. Data Source and Demographics

A questionnaire in a survey form administered to a total of ninety participants working in the manufacturing industry in the Philippines. A total of sixteen selected equipment warning signs are common to manufacturing equipment following the International Organization for Standardization, ISO standard warning signs (ISO7010:2019- Graphical symbols) (Table 1).

Table 1. ISO Standard Warning Signs

no.	SYMBOL	DESCRIPITION	no.2	SYMBOL2	DESCRIPITION2
1		START AUTOMATICALLY	9		HOT SURFACE
2		BIOLOGICAL HAZARD	10		LASER BEAM
3		CORROSIVE SUBSTANCE	11		LOW TEMPERATURE
4		COOUNTER ROTATING ROLLERS	12		OPTICAL RADIATION
5		CRUSHING BY MOVING PARTS	13		OVERHEAD OBSTACLE
6		CRUSHONG OF HANDS	14		OXIDIZING SUBSTANCE
7		ELECTRICITY	15		SHARP ELEMENT
8		EXPLOSIVE MATERIALS	16		RADIOACTIVE MATERIAL

Below were the demographics of respondents shown in Table 2. A total of 90 respondents chosen from different gender, educational background, position, and identified if handles machine directly or indirectly.

Table 2. Respondents' Demographics

Description	Count	Percentage
Gender		
Male	65	72%
Female	25	28%
Educational		
secondary	5	6%
Vocational	29	32%
College	47	52%
Graduate	9	10%
Position Level		
Manager	7	8%
Engineer	19	21%
Leader	11	12%
Technician	39	43%
Operator	14	16%
Handles Machine		
Direct	64	71%
Indirect	26	29%
Marital Status		
Single	39	43%
Married	51	57%
Experience		
0-10 yrs	54	60%
11 above	36	40%

3.2. Equipment and Software Applications

Create a questionnaire in the survey format using Google Forms online application. All the sixteen selected warning signs photo was uploaded and make all its description as part of the dropdown answer selection list. After creating the survey and already available online, it was accessed using their laptops, cellphones, and works station computers on the production floor.

For this study, as discussed, the data analysis used is the quantitative-descriptive analysis using the SEM (Structural Equation Modelling) method. In this case, it requires the acquisition and installation of IBM SPSS (Statistical Package for the Social Sciences) statistical software and the IBM AMOS Graphics to be used for data analysis. Also, required to install Minitab Statistical Analysis software as supporting software for data analysis.

3.3. Procedure and Instructions

The questionnaire administered to a total of 90 respondents right after orientation on how to answer each warning sign description. The first part of the survey requires the details of the respondent, name, gender, age, work experience, position, and if he/she directly handles machine equipment. The next part is the presentation of photo for each warning sign and would require answering the sign description appropriate for the symbol via a dropdown list menu, having all the sixteen warning sign descriptions, shown in Figure 3. The dropdown list randomly changes position in the list to avoid guessing and comparing the answer with other respondents.

After completion of the sixteen-warning sign, a submit button is then made available at the last warning sign survey. The respondent has the option to view his/her score and check the correct for the incorrect answers.

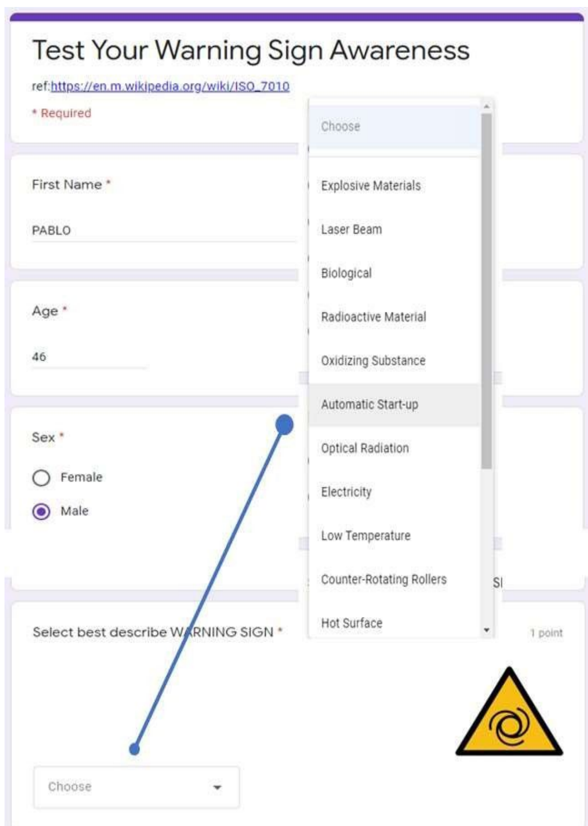

Figure 3. Sample Survey 1 Form Screen

Upon completion of the 90 respondents, all raw data is available to download from the google forms in excel format. All the information is ready for the profile and data coding, as shown in Table 3, in preparation for data analysis.

Table 3. Respondents' Profile Coding

Description	Abbreviation	Numerical Code	Measure
Comprehension Score	CS	-	scale
Comprehension Percent	CP	-	scale
AGE	Ag	-	scale
Work Experience	WE	-	scale
Marital Status	MS	-	-
Single	-	1	nominal
Married		2	nominal
Gender	SX	-	-
Male	-	1	nominal
Female		2	nominal
Educational Attainment	EA	-	-
Elementary		1	ordinal
High School	-	2	ordinal
Vocational		3	ordinal
College	-	4	ordinal
Graduate		5	ordinal
Position Level	POS	-	-
Operator	-	1	ordinal
Technician	-	2	ordinal
Leader	-	3	ordinal
Engineer	-	4	ordinal
Manager	-	5	ordinal
Handles Machine	HM	-	-
Direct	-	1	nominal
Indirect	-	2	nominal

The result of these questionnaires will generate a list of warning signs comprehension level below eighty-five percent standard as defined by the American National Standards Institute, ANSI (ANSI Z535.3;2011). The list of warning signs that fails will again undergo an evaluation as against the ergonomic principles, cognitive compatibility, conceptual compatibility, physical representation, familiarity, and standardization, through scaled numerical value and will be the basis of the two proposed redesigns alternative warning sign.

The evaluation will be carried out by the considered experienced in the industry. An evaluator selection carried out from 90 respondents, based on following these criteria; a perfect comprehension score, with a minimum college degree, and experience in the same industry for more than ten years.

The top five selected evaluators are again presented with the new list of warning signs and will rate the two propose designs according to ergonomic principles. The rating will also use as inputs for the decision analysis in the AHP method to select the most appropriate alternative warning sign.

The third set of a questionnaire administered to a new set of 90 respondents to test the effectiveness of the chosen best appropriate alternative redesigned warning sign using the 2-tailed-t hypothesis test. (Figure 4)

Figure 4. Sample Survey 2 Form Screen

Above survey, the screen shows two different alternative warning sign designs to consider for the evaluator to rate from 1-9 according to compliance to stated ergonomic principles.

4. Results and Discussion

The data collected for this study tested using SPSS Statistic software, if it is feasible for analysis, using scale reliability analysis Cronbach's Alpha and determine the internal consistency of each data items. In the measure of warning signs comprehension, multiple data analyses applied.

4.1. Comprehension Scores

In obtaining the comprehension score for each sixteen-machine warning sign, all results in the questioner of 90 respondents are summarized. Table 4 shows the results of each sign wherein the incorrect answer coded as 1, and the correct answer as 2.

In computing the comprehension score, it considers the correct answer. For instance, the warning sign number 1 only had 34 out of 90 respondents correctly identified the sign; this corresponds to a 38% comprehension score, as shown in Table 4 post-comprehension score (Table 4).

Table 4. Aggregated Response Matrix for each Warning Sign and One-way ANOVA results

DESCRIPTION	COUNT	%																	AVE	R-sq	*p-value*
Gender																					
Male	65	**72%**	42%	77%	80%	80%	78%	86%	100%	89%	98%	86%	86%	74%	92%	65%	85%	83%	**81%**	0.987	0.015
Female	25	**28%**	28%	56%	76%	60%	80%	96%	96%	76%	92%	72%	96%	72%	96%	60%	80%	72%	**76%**	0.936	0.000
AGE																					
40 and above			48%	85%	93%	85%	85%	81%	100%	96%	96%	89%	89%	78%	89%	78%	93%	89%	**86%**	0.918	0.001
above 40			44%	67%	100%	89%	89%	100%	100%	89%	100%	89%	100%	78%	100%	67%	89%	89%	**87%**	0.888	0.000
EDUCATION																					
secondary	5	**6%**	20%	20%	100%	40%	100%	100%	100%	0%	80%	40%	100%	80%	100%	0%	80%	20%	**61%**	0.425	0.016
Vocational	29	**32%**	38%	59%	72%	66%	72%	83%	100%	79%	97%	76%	62%	62%	93%	45%	79%	72%	**72%**	0.999	0.000
College	47	**52%**	40%	85%	81%	81%	81%	91%	98%	96%	98%	89%	89%	79%	94%	81%	87%	89%	**85%**	0.936	0.006
Graduate	9	**10%**	33%	67%	78%	89%	78%	89%	100%	100%	100%	89%	100%	89%	89%	67%	89%	78%	**83%**	0.858	0.000
POSITION LEVEL																					
Manager	7	**8%**	43%	86%	86%	100%	100%	100%	100%	100%	100%	86%	100%	71%	100%	86%	100%	100%	**91%**	0.757	0.001
Engineer	19	**21%**	32%	89%	84%	84%	68%	89%	95%	95%	95%	89%	95%	79%	89%	68%	84%	89%	**83%**	0.823	0.002
Leader	11	**12%**	36%	82%	82%	82%	64%	82%	100%	91%	91%	91%	91%	82%	91%	82%	82%	73%	**81%**	0.827	0.001
Technician	39	**43%**	44%	72%	69%	69%	77%	85%	100%	85%	97%	82%	77%	72%	92%	92%	79%	82%	**80%**	0.839	0.027
Operator	14	**16%**	29%	29%	86%	57%	100%	93%	93%	57%	93%	57%	100%	64%	100%	36%	86%	57%	**71%**	0.754	0.021
HANDLES MACHINE																					
Direct	64	**71%**	45%	66%	75%	69%	78%	91%	100%	83%	98%	80%	88%	72%	94%	61%	83%	77%	**79%**	0.999	0.018
Indirect	26	**29%**	19%	85%	88%	88%	81%	85%	96%	92%	92%	88%	92%	77%	92%	69%	85%	88%	**82%**	0.916	0.001
MARITAL STATUS																					
Single	39	**43%**	45%	75%	82%	80%	80%	86%	100%	88%	98%	84%	86%	78%	96%	69%	86%	82%	**82%**	0.990	0.002
Married	51	**57%**	28%	67%	74%	67%	77%	92%	97%	82%	95%	79%	92%	67%	90%	56%	79%	77%	**76%**	0.997	0.000
EXPERIENCE																					
0-10 yrs	54	60%	31%	65%	69%	67%	74%	91%	98%	80%	96%	78%	87%	70%	94%	56%	78%	74%	**75%**	0.996	0.002
11 above	36	40%	47%	81%	94%	86%	86%	86%	100%	94%	97%	89%	92%	61%	92%	75%	64%	89%	**83%**	0.995	0.009
COMPREHENSION SCORE		**overall %**	**38%**	**71%**	**79%**	**74%**	**79%**	89%	99%	86%	97%	**82%**	89%	**73%**	93%	**63%**	**83%**	**80%**	**80%**		

Out of 16 warning signs, 9 of which obtained comprehension score lower than 85% (scores in red font), these scores imply unacceptable comprehensibility level as against to ANSI standard acceptable comprehension level. Also, 3 out of 16 obtain a comprehension score lower than 72.72% as against to Organization International Standardization-ISO (ISO 3864; 2011).

4.2. Comprehension Factors

The comprehension score shown in Table 4 for each warning sign aggregated results; also displays results of One-way Analysis of Variance (ANOVA) to compare each factor as against comprehension scores.

4.3. Data Analysis

Before the implementation of hypotheses, data are all tested with the use of the SPSS Reliability Statistics Data Analysis function (Table 5).

Table 5. Cronbach's Alpha

Reliability Statistics	
Cronbach's Alpha	.760
Cronbach's Alpha Based on Standardized	0.740
N of Items	16

Cronbach's Alpha result shows that the sample is consistent and reliable, as it results in 0.760, which meets the acceptable requirement of 0.60 to 0.70 (table 6)

Table 6. Item Total Statistics

Item-Total Statistics				
#	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Cronbach's Alpha if Item Deleted
Q1	27.3778	7.047	0.262	0.760
Q2	27.0444	6.650	0.470	0.736
Q3	26.9667	7.156	0.290	0.754
Q4	27.0111	6.708	0.467	0.737
Q5	26.9667	7.044	0.344	0.749
Q6	26.8667	7.533	0.190	0.760
Q7	26.7667	7.956	-0.009	0.765
Q8	26.9000	7.125	0.377	0.746
Q9	26.7889	7.786	0.142	0.761
Q10	26.9333	6.760	0.528	0.732
Q11	26.8667	7.330	0.311	0.752
Q12	27.0222	6.651	0.485	0.735
Q13	26.8222	7.564	0.243	0.756
Q14	27.1222	6.738	0.393	0.745
Q15	26.9222	7.106	0.358	0.748
Q16	26.9556	6.605	0.578	0.726

The item total statistics shows that all items except Q7 which is slightly higher, shows lower 0.760 Cronbach's Alpha when item was deleted. With all the above Cronbach's Alpha results in it shows that data is reliable for the study.

4.4. Hypotheses Modelling

A comprehension framework created to achieve the goal of the study, which is to define inherent factors affecting warning sign comprehension. Profile and resulting data assign as exogenous and endogenous interrelated variables. (Figure 5)

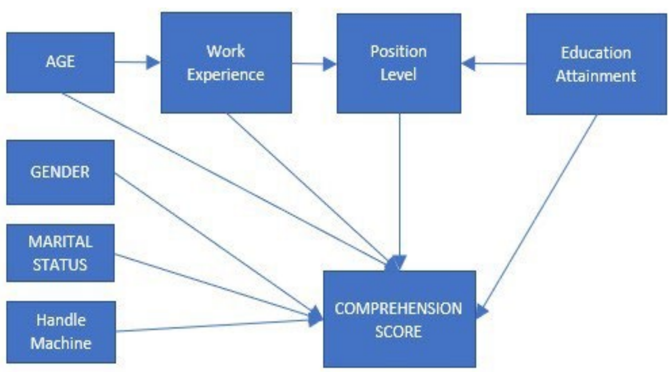

Figure 5. Conceptual Framework

Based on Figure 5 framework, the hypotheses in this study were;

H1: Educational Attainment influence Comprehension Score.
H2: Position Level influence Educational Attainment that mediates its influence on Comprehension Score.

H3: Position Level mediates the influence of Work Experience on Comprehension Score.
H4: Work Experience mediates the influence of Age to Comprehension Score.

4.5. Variable Considerations

Only observed variables considered in the structural modeling, and no identified unobserved variables or latent. Also, variables influence by other variables assigns with errors. Covariances in between variables considered to observe their relations (Figure 6).

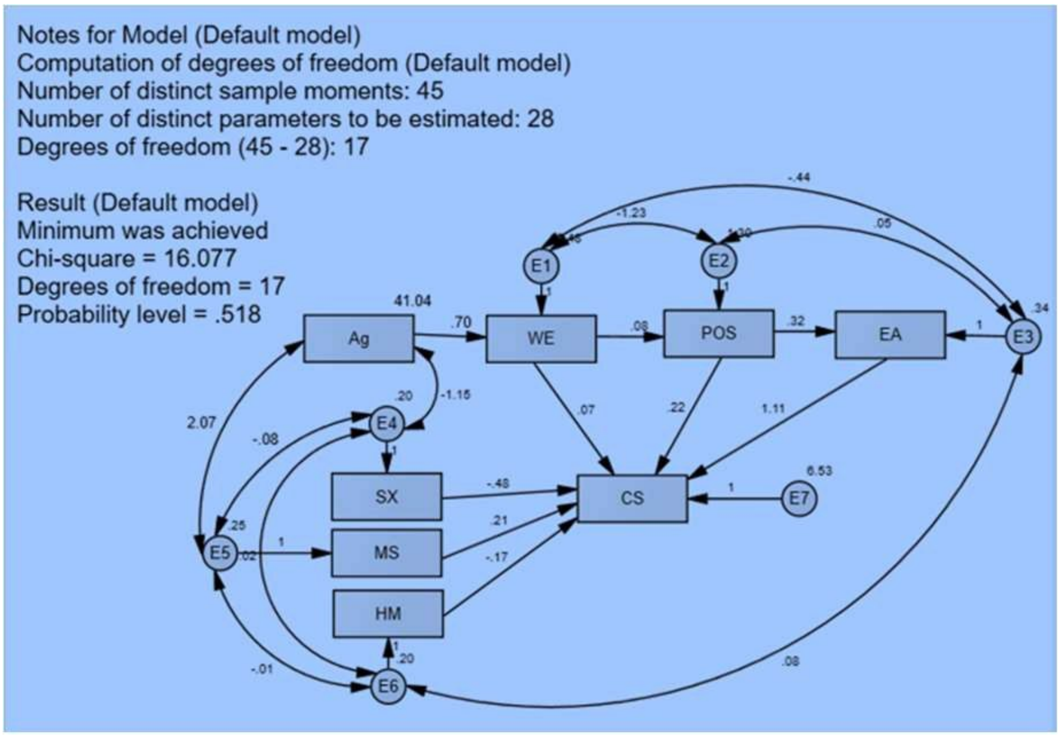

Figure 6. Structural Model

The actual structural model diagram with a degree of freedom of 17 (positive), Chi- Square is 16.077 (accept), and a significant probability level of 0.518 is good with a cut-off value of ≥ 0.05.

Table 7a. Goodness of Fit

Model	RFI	IFI	TLI	CFI
Default model	0.963	0.903	1.001	1
Saturated model		1		1
Independence model	0	0		0
Cut-off Value	≥ 0 .90	≥ 0 .90	≥ 0 .90	≥ 0 .90
Information	Good	Good	Good	Good

Table 7b. Goodness of Fit

Model	GFI	AGFI	PGFI	NFI
Default model	0.963	0.903	0.364	0.989
Saturated model	1			1
Independence model	0.514	0.393	0.411	0

Cut-off Value	≥ 0 .90	≥ 0 .90	≥ 0 .90	≥ 0 .90
Information	Good	Good	Good	Good

The of Goodness of fit indices shows a good measure, shown in Table 7a and Table 7b. These suggest that the hypothesized model and the covariance matrix are acceptable.

Table 8. Regression Weights

			Estimate	S.E.	C.R.	P
WE	<-------	Ag	0.753	0.065	10.793	***
POS	<-------	WE	0.412	0.028	2.972	0.003
EA	<-------	POS	0.549	0.159	2.026	0.043
CS	<-------	SX	-0.077	0.658	-0.736	0.462
CS	<-------	MS	0.036	0.654	0.314	0.754
CS	<-------	HM	-0.027	0.631	-0.264	0.792
CS	<-------	POS	0.092	0.288	0.751	0.452
CS	<-------	WE	0.140	0.054	1.212	0.226
CP	<-------	CS	1.000	0.000	682.57	***

4.6. Alternative Redesign using AHP

The evaluation result following ergonomic principles as input in the AHP process determines the priority criteria in the design of alternative warning signs; Figure 7 shows the alternative for a radioactive symbol. The ergonomics principles like familiarity is a strong influence on comprehension as shown in the outcome of pre-comprehension. In this instance, an unfamiliar sign should be supplemented by text to aid in the learning of its meaning and improve memory retention (Shinar and Vogelzang, 2013).

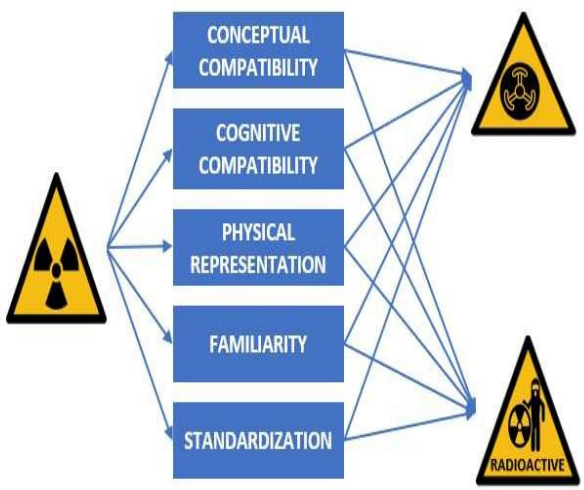

Figure 7. Alternative Design – AHP structure

Table 9. Design Criteria- AHP

	COGNITIVE	CONCEPT	PHYSICAL	FAMILIARITY	STANDARD
COGNITIVE	1.000	0.125	6.000	9.000	4.000
CONCEPT	8.000	1.000	8.000	9.000	4.000
PHYSICAL	0.167	0.125	1.000	9.000	8.000
FAMILIARITY	0.111	0.111	0.111	1.000	0.125
STANDARD	0.250	0.250	8.000	0.250	1.000
sum	9.528	1.611	23.111	28.250	

COGNITIVE	0.105	0.078	0.260	0.319	0.234	0.199
CONCEPT	0.840	0.621	0.346	0.319	0.234	0.472
PHYSICAL	0.017	0.078	0.043	0.319	0.467	0.185
FAMILIARITY	0.012	0.069	0.005	0.035	0.007	0.026
STANDARD	0.026	0.155	0.346	0.009	0.058	0.119
checksum	0.962	0.776	0.649	0.956	0.934	

Table 10. Evaluation of Alternative Design – AHP

	COGNITIVE	CONCEPT	PHYSICAL	FAMILIARITY	STANDARD
Design A	4.00	6.00	4.00	6.00	6.00
Design B	9.00	9.00	9.00	9.00	9.00
sum	13.00	15.00	13.00	15.00	15.00
	COGNITIVE	**CONCEPT**	**PHYSICAL**	**FAMILIARITY**	**STANDARD**
Design A	0.31	0.40	0.31	0.40	0.40
Design B	0.69	0.60	0.69	0.60	0.60

Multiply the Column-normalized matrix by the Weights column vector to yield the SCORES column vector.

SCORES:

Design A 0.365

Design B 0.635 Highest is recommended

checksum 1.000

Table 9 and Table 10 show the AHP sample process and results on the decision of warning sign design B alternatives. With the result of the evaluation and the AHP method, selection for best suited alternative warning sign design decided.

Table 11. AHP Semantic Scale Reference

Numerical Rating	Description
1	Equally Preferred
3	Moderately Preferred
5	Strongly Preferred
7	Very Strongly Preferred
9	Extremely Preferred
2,4,6,8	All in between

Table 11 shows the AHP semantic scale of reference for preference in judgement of the proposed warning sign design criteria. In relation to warning sign comprehension level. The individual evaluation rate for each alternative design in compliance with ergonomics principles applied is shown in Table 12.

Table 12. Ergonomic Compliant Alternative Sign

DESCRIPTION	R-sq	p-value	STARTS AUTOMATICALY	BIOLOGICAL HAZARD	CORROSIVE SUBSTANCE	COUNTER ROTATEROLLERS	CRUSHING BY MOVING PARTS	LASER BEAM HAZARD	OPTICAL RADIATION	OXIDIZING SUBSTANCE	RADIOACTIVE MATERIALS	SHARP ELEMENT	AVE
Ergonomic Principles (Ave.Score)													
Cognitive Compatibility	0.583	0.676	7.0	7.8	7.8	8.2	8.0	5.8	8.0	7.2	8.0	8.4	7.6
Conceptual Compatibility	1.000	<0.001	7.8	8.0	8.2	8.4	8.6	5.8	7.8	7.4	8.6	8.4	7.9
Physical Representation	0.375	0.779	7.0	8.6	9.0	9.2	9.0	7.0	8.6	8.2	9.0	8.8	8.4
Familiarity	0.687	0.302	8.4	8.2	8.2	9.2	9.2	8.0	8.6	8.4	9.2	9.0	8.6
Standardization	0.687	0.510	7.2	8.6	8.0	8.6	7.8	8.4	8.4	6.0	7.8	9.0	8.0
		Ergonomic Score (ave)	7.48	8.24	8.24	8.72	8.52	7.00	8.28	7.44	8.52	8.72	8.12
		POST -Comprehension Score, %	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	0.998
No. of Response, count													
Correct	-	-	89	90	90	90	90	90	89	90	90	90	-
Incorrect	-	-	1	0	0	0	0	0	1	0	0	0	-
		PRE -Comprehension Score, %	0.38	0.71	0.79	0.74	0.79	0.82	0.73	0.63	0.83	0.80	0.800
		Comprehension Gap, %	0.61	0.29	0.21	0.26	0.21	0.18	0.26	0.37	0.17	0.20	0.198

The table 12 also shows the gap in pre and post comprehension; it shows a significant increase in average score from 80% to 99.8%, way high compared to the 85% requirement.

5. Discussion

Table 8 Shows Educational Attainment (EA) has strongest influence on Comprehension Score (CS), (β = 1.106; p-value = < 0.025), and it is significant, it implies H1 hypothesis is accepted. The importance of identification of EA as the primary factor affecting the CS gives us the idea to zoom in to people who belong under these groups of workers. Safety activity is costly if implemented across the organization. This study justifies prioritization to a limited group, thus limiting the cost, yet maximizing the impact of implementation.

The Position Level (PL) with a result of (β = 0.322; p-value = 0.043), influences EA, with this, H2 is accepted. These factors are interrelated, yet PL level is not significantly affecting CS. It shows that safety-related activities should not focus more on PL. Regardless of the PL, one should undergo safety training and orientation, particularly on warnings sign.

Work Experience (WE), has direct influence to Position level, (β = 0.083; p-value = 0.003), and mediates its influence to CS, these results accept H3. Most experience people held a higher position. This result reveals that it thus not except experience workers to undergo safety orientation. As shown, WE □ CS result, with p-value = 0.003.

The age influence Work Experience, (β = 0.703; p-value = <0.001), and mediates its influence to CS, with this H4 hypothesis, accepted. It is another obvious result, but since hypothesis 3 shows WE □ CS has no significant impact, it suggests that age and work experience is not a priority factor in the selection of target safety participants.

In the prioritization of safety activities, participants should mainly select according to their educational attainment. The workers' age, sex, position level, work experience, and handling machine is not a factor affecting warning sign comprehension score.

While in the evaluation of warning signs shows a strong relationship concerning one or more of the ergonomic principles. For instance, the warning sign for electricity hazard gains the highest comprehension score at 99%. It is because a vast number of people are familiar with the symbol of lightning as electricity. Also, the warning sign for an overhead obstacle with a 93% comprehension score shows an excellent physical representation of its warning sign.

This observation leads to redesigning of sign based on ergonomics principles — it shows in the above results of a comprehension score improvement.

6. Conclusion

The research hypotheses show rigid results and that some factors have an influence on the warning sign comprehension and should take into consideration in the implementation of safety programs. This study concludes that *educational attainment is an identified factor that has the strongest and significant influence on safety comprehension,* , that higher education is a strong influence on the safety comprehension at the workplace. *On the other hand, regardless of position level, work experience and age it has no direct influence on comprehension score.* The recommendation is to focus on resources of safety awareness and prioritize training more on workers concerning their level of educational attainment and work experiences. They were a group of workers that is at high risk of being involved in an accident in the workplace, and it is essential to give special attention to this group.

Also, it further strengthens the theory that ergonomic principles improve the warning sign symbols comprehension, including the manufacturing industry. It is of high importance to design warning sign that is actively compliant to ergonomic design principles, and this study was able to successfully redesign a new set of warning sign that fails the initial comprehension level evaluation.

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