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The Effects of Training Intervention on Knowledge Level of Occupational Risk Assessment among Engineering Students in a Public University in Selangor

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ABSTRACT

Knowledge on occupational safety is crucial in the engineering field. In addition to reducing workplace risks, solid understanding on the basics of occupational safety and how it corresponds to health in the specific direction of Occupational Safety and Health (OSH) will develop engineers with improved ability to ensure safety and health performance. Current curriculum for engineering requires OSH-specific training to be incorporated in body of knowledge. This study aims to assess the effects of OSH risk assessment training on knowledge level among final year engineering students in a local university in Malaysia. Method: This was a one-group pre-test and post-test quasi experimental design conducted among 70 civil, agricultural and mechanical engineering students in a public university in Malaysia. An OSH risk assessment training module based on Hazard Identification, Risk Assessment and Risk Control (HIRARC) guideline was developed and validated as the intervention tool and a 20-item questionnaire was employed as assessment tool disseminated at pre- and post-test stage to evaluate knowledge level. The intervention was delivered in classroom settings and participants answered a self-administered questionnaire at pre- and post-delivery of the training. Data collected was entered into statistical program and was analysed according to objectives. Results: Majority were males (54%), less than 23 years old (29%) and had cumulative grade of 3.0-3.5 (67%). The average (median ± interquartile range) knowledge scores at pre- and post- test stage were 10 (9-11) to 14 (13-15). There was a significant ($p<0.05$) increase in knowledge level at the post-test stage. Implications: The HIRARC training module developed has a potential to increase knowledge on risk assessment among engineering students. Knowledge on risk assessment will enable engineers to eliminate hazards in the conceptual or designing phase of engineering work, thus reducing probability of accidents and ill-health from occurring in workplace.

Keywords:
Engineering; hazard Identification Risk Assessment and Risk Control (HIRARC), knowledge; training

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1. Introduction

The field of engineering combines various fundamentals such as mathematics, science and technology and comprise of major branches of disciplines such as chemical, mechanical, civil, aviation, aerospace and others. Engineering students are taught significant amount of fundamental knowledge related to the chosen field of study in addition to safety aspects within a system, however there are evidence that highlights the need for higher knowledge on occupational safety to help reduce accidents at the workplace [1-3]. Engineers remain one of the most important educational backgrounds of professionals within the Occupational Safety and Health (OSH) discipline [4]. Knowledge on occupational safety is crucial for the various teams involved during designing stage of engineering works because they have the opportunity to eliminate hazards and reduce risks as compared to other professions [5]. To prevent and control occupational injuries, illnesses and fatalities, control measures must be implemented at the earliest stage when designing to minimise risk [5,6]. For example, scholars have acknowledged that “Prevention through Design” (PtD) in construction as one of the proactive efforts to reduce hazards and risks throughout the design phase with the overarching aim to balance occupational safety and health over the project lifecycle [7]. PtD is also a concept indicated in the Malaysian Guidelines of OSH in Construction Industry (Management) [8] which was adopted from United Kingdom (UK). Lack of safety measures being implemented during the design process were reported to be due to the mindset of the designer, lack of knowledge on work tasks and lack of understandings on safe practices at work [9]. Solid understanding on the basics of occupational safety and how it corresponds to health of the end user in the specific idea of OSH will develop engineers with improved ability to design machines that can be built with better safety measure.

In higher education institutes, OSH-related courses has been incorporated into curriculums of engineering schools [4]. In fact, majority of academic courses related to OSH in Europe has been organised by engineering schools [10] and the need for OSH courses in engineering classrooms during formal education has long been reported since 1999 [11]. With respect to engineering courses in tertiary education in Malaysia, the Malaysian Qualification Agency (MQA) has set the benchmark for engineering and engineering technology standards in its guideline released in 2011 [12]. Among its program outcomes adapted from Sydney Accord revolves around design solutions for engineering technology systems [12]. This is to meet specific needs for health and safety responsibilities with consideration to public health [12]. Hence crucial body of knowledge on OSH has been or must be incorporated into curriculum.

Risk assessment methodologies are varied and according to ISO 31010:2019 Risk Management Techniques [13] there are more than 30 methods for risk assessment. Among the most notable method used in the Malaysian industrial setting is Hazard Identification Risk Assessment and Risk Control (HIRARC) [14]. HIRARC is a tool to identify hazards and assess associated OSH risks as well as to provide specific suggestions to control the risk. Risk assessment is a semi-quantitative tool and is key in reducing incidents and preventing near-miss in the workplace. Researchers have emphasised the need for OSH-related training including risk analysis for engineers and education for engineering students to be developed in college, schools and professional associations, to provide valuable tools to improve safety performance [3,15]. With the many possible catastrophic scenarios that the world is experiencing, engineers need to be more prepared for risk assessment and management [16].

In literature, examples of studies relating to various OSH awareness or knowledge among vocational and engineering students has been reported globally [17-22]. However, studies relating to effects of training on OSH risk assessment among engineering students has been limited to a few [3,23]. Effects of training on OSH risk assessment among engineering students has yet to be reported for Malaysia. Awareness on risk assessment fundamentals needs to be encouraged because legal requirements declares that safety is the responsibility of every person in an organization and is not restricted as a job for a person involved with safety and health work such as the employer, safety officer or the safety and health committee [24]. As such, this study aims to assess the effects of OSH risk assessment training on knowledge level among final year engineering students in a local university in Malaysia. This study will provide basic information which can be used by the higher education sector to evaluate and re-assess the current engineering students' curriculum. As a result, continuous improvement to strengthen the curriculum to improve the education system can be performed to prepare graduates that will be working in industries.

2. Materials and Methhodology

2.1 Study Design and Study Location

This is one group pre- and post-test quasi experimental study. This study was carried out in an engineering faculty of a public university in central Malaysia. The university was chosen as the study location as it is one of the five research universities in Malaysia and is located centrally in the Klang Valley. The engineering subjects in this public university has been ranked among the best 100 in QS world University Ranking in 2018. This study was conducted between September 2018 to April 2019.

This study developed a training module as an intervention tool and a related questionnaire was then developed from the training module to be used as an assessment tool. The scores obtained from the completed assessment tool were then used to compare knowledge level of risk assessment.

2.2 Study Population and Sampling Method

The target population of this study was the 4th or final year undergraduate engineering students from the selected university. The sampling frame of this study was the list of Malaysian students that is in their 4th year of study in engineering courses in the university regardless of gender. The reason why only final year students were selected as the target population in this study was that to make sure they had already studied most of the engineering subjects and that they already attended and completed their industrial training for 10 weeks. The sampling method used was convenient sampling method.

2.3 Study Instruments

The intervention tool consists of a module which was presented to participants in the form of slide presentations. The intervention tool and the questionnaire to assess the effects of the training module was developed by the researchers and all the information were adapted from the guidelines by Department of Occupational Safety and Health (DOSH) on risk assessment used widely in Malaysia which is the HIRARC method [14].

2.3.1 Training Module

The training was given by one the researcher and took place immediately after the participants answered the pre-intervention questionnaire. The session was completed within one hour. To evaluate the increase in knowledge, the same questions were used for the pre- and post-intervention.

To deliver the module effectively, the researcher attended courses related to presentation skills such as Academic Interaction and Presentation and Communication and Professional Development. The researcher trained to deliver the module with the research team before training actual participants.

Presentation was given in small groups of 5 at different days based on the participants' convenience in between classes. The lecture method was used because in the study done by Sajjad [25] concluded that students preferred the lecture method the most when compared to other methods.

The training consisted of the following sub-topics:

1. Introduction Occupational Safety and Health (OSH)
2. Heinrich triangle
3. Hierarchy of control
4. Type of hazards
5. Hazard, Identification, Risk Assessment and Risk Control (HIRARC)

2.3.2 Questionnaire

Questionnaires was used as the main study instrument to assess the effects of the given intervention. The questionnaire was provided in English language and consisted of two sections as below.

Section A: Socio-Demographic

In this section, several questions such as gender, age, ethnicity, engineering course, industrial training sectors and past training involvement in OSH were asked.

Section B: Knowledge on Hazard Identification, Risk Assessment and Risk Control (HIRARC)

This section consists of items on HIRARC and the survey was done to examine the knowledge of study participants on HIRARC. This study was only focused on assessing the level of Knowledge as the main element because the element of Attitude and Practice were not practicable to the engineering student as they only apply the information when they are working at a later stage. This study compared the current knowledge of the participants and the changes in knowledge level after training on HIRARC has been implemented.

The pre-intervention questionnaire which consisted of section A and B and was given in hardcopy. For post-intervention, only section B were administered to the participants and it was given in the form of online quiz by using an application called Kahoot! to incorporate the element of gaming into the intervention process. At the end of the online quiz, the application will summarize results from the participants and project in onto the device of the administer while scores were provided in the application in the form of Excel sheet that were downloaded for analysis.

Section B consist of 20 items or questions and options for answers were provided in the form of True, False and Don't Know. There were positive and negative type of questions. One score was given for each correct answer while zero is given for each wrong and Don't Know answer. The scores were summed and were categorised into three levels which was high (71%-100%) or scores from 14 to 20, medium (51%-70%) or scores from 10 to 13 and low level (less than 50%) or 0 to 9 [26].

2.4 Study Instruments

The questionnaire and training module were validated and reviewed by three experts including an academic who was trained as an engineer in the OSH field from the Department of Environmental and Occupational Health, UPM. This is to ensure that the questions are valid and relatable with the study objectives and the discipline of the engineering field.

A pre-testing which includes the administration of the questionnaire and training module were conducted among a group of engineering student (10% from the study sample size) from the same engineering faculty. The researcher who delivered the training module is well-versed on HIRARC and had already been trained to practice HIRARC in real workplace environment.

The value for internal consistency for the items on knowledge of HIRARC was tested by using the Cronbach's Alpha analysis and the value obtained was 0.629. Based on the study by Ahdika [27], Cronbach's Alpha score between 0.6 to 0.8 was considered as reliable. In the pre-test, participants were asked to point out any ambiguous terms in the questionnaire and training module. These were corrected before being administered to the study participants. The results from the pre-test were not included in the result of the study

2.5 Ethical Considerations

This study had obtained ethical approval from the Institutional Review Board with reference number of UPM/TNCPI/RMC/1.4.18.2. Written consent was obtained from the participants prior to the study. All information obtained from the respondents were used for this study's purposes only.

3. Results
3.1 Socio-demographic Distribution

This study involved a total of 70 respondents which comprised of 38 (54.3%) males from three different courses namely 28.6% (n=20) Civil Engineering, 38.6% (n=27) Agricultural and Biosystem Engineering and 32.9% (n=23) Mechanical Engineering. Most of them were below 23 years old (62.8%; n=44) and 85.7% (n=60) of them were Malay. In terms of academic grades (Cumulative Grade Point Average, CGPA), most of them (n=47; 67.1%) were between 3.00 to 3.50. Table 1 describes the socio-demographic background of the engineering students who participated in this study (n=70).

Table 1
Socio-demographic background of engineering students in a public university (n=70)

Variables	Items	N=70	
		Frequency (%)	**Mean (SD)**
Gender	Male	38 (54.3)	
	Female	32 (45.7)	
Age	<23	44 (62.8)	23.76 (1.31)
	24-25	17 (24.3)	
	>26	9 (12.9)	
Courses	Civil Engineering	20 (28.55)	
	Agricultural and Biosystem Engineering	27 (38.55)	
	Mechanical Engineering	23 (32.90)	
Race	Malay	60 (85.7)	
	Others	10 (14.3)	
CGPA	<3.000	11 (15.7)	
	3.000-3.500	47 (67.2)	

	3.501- 4.000	12 (17.1)
School	National Secondary School	41 (58.6)
	Secondary School	3 (4.3)
	Technical or Vocational Secondary School	8 (11.4)
	National Religious Secondary School	2 (2.9)
	Fully Residential School	16 (22.8)

In terms of industrial training, 14 (20.3%) of the students went for industrial training in the manufacturing sector, 22 (31.9%) went into the construction sector, 18 (26.1%) of them did their industrial training in the agriculture sector and 16 (21.7%) of them went to other sectors such as oil and gas, consultancy, aquaculture and power plant station. Half of the students had already attended training related to OSH. Some of the training were given by authority bodies such as the Construction Industry Development Board (CIDB) Malaysia while others were given in-house by experts from chemical manufacturing and oil refinery industry. Other related training includes cardiopulmonary resuscitation (CPR) training, Occupational Safety and Health seminar and confine space-related training such as inert entry training and blue card training. The other 50% (n=35) of the students have not attended any training related to OSH.

When being asked about which sectors they wish to work for in the future, 26.1% (n=18) of them wish to work in the manufacturing sector, 30.4% (n=20) wished to work in the construction sector, 26.1% (n=17) in the agriculture sector and another 17.4% (n=15) wished to work in other sectors such as aviation, oil and gas, consultancy and oleochemical sector. Lastly, when being asked to rate their perception on knowledge level related to OSH, about 63% (n=44) of the participants perceived themselves to have good knowledge level. Table 2 presents distribution of exposure to OSH reported by the participants.

Table 2
Exposure to OSH reported by engineering students in a public university (n=70)

Variables	Items	N=70	
		Frequency	Percentage (%)
Industrial training sector	Manufacturing	14	20.3
	Construction	22	31.9
	Agriculture	18	26.1
	Others	16	21.7
Training attended related to OSH	No	35	50.0
	Yes	35	50.0
Sectors to work for in the future	Manufacturing	18	26.1
	Construction	20	30.4
	Agriculture	17	26.1
	Others	15	17.4
Perception of own knowledge related to OSH	Very low	1	1.5
	Low	7	10.3
	Not sure	18	25.0
	Good	39	54.4
	Very good	5	8.8

3.2 Overview of Knowledge Scores and Level on HIRARC at Pre- and Post-Intervention Stage

In general, almost all items in the questionnaire had a higher shift in the frequencies of correct answer at the post-intervention stage. Table 3 presents the frequency distributions of correct and wrong answers scored at the pre- and post-intervention stage by the participants.

Table 3
Frequency distribution of correct and wrong answers of knowledge on HIRARC scored at the pre- and post-test stage (n=70)

No.	Questions	Pre-intervention		Post- intervention	
		Frequency (%)			
		Correct	Wrong	Correct	Wrong
1	HIRARC is important to ensure that risks at the workplace are adequately controlled at all times.	69 (98.6)	1 (1.4)	70 (100)	0 (0)
2	The machine design has nothing to do with an accident that happens in the workplace.	62 (88.6)	8 (11.4)	68 (97.1)	2 (2.9)
3	Heinrich concludes that for every 1 major injury there is 27 accident that causes minor injury.	2 (2.9)	68 (97.1)	38 (54.3)	32 (45.7)
4	HIRARC can only be done by the Safety and Health Officer in a company.	13 (18.6)	57 (81.4)	61 (87.1)	9 (12.9)
5	HIRARC provides a systematic and objective approach to assess the hazard.	60 (85.7)	10 (14.3)	66 (94.3)	4 (5.7)
6	It is not necessary to keep a record on the hazard that has been identified.	61 (87.1)	9 (12.9)	63 (90.0)	7 (10.0)
7	A new machine that already has guard installed does not need HIRARC to be done.	61 (87.1)	9 (12.9)	65 (92.9)	5 (7.1)
8	Doing maintenance to machine breakdown is consider as routine work.	16 (22.9)	54 (77.1)	25 (35.7)	45 (64.3)
9	Hazard is the process of evaluating risks to safety and health arising from hazards at work.	10 (14.3)	60 (85.7)	20 (28.6)	50 (71.4)
10	Using first aid record is one of the techniques to identify hazards.	53 (75.7)	17 (24.3)	48 (68.6)	22 (31.4)
11	A near miss that occur in the workplace needs to be reported to the employer or line leader.	67 (95.7)	3 (4.3)	63 (90.0)	7 (10.0)
12	Hazards are divided into five main groups-health, biological, physical, chemical and ergonomic.	1 (1.4)	69 (98.6)	15 (21.4)	55 (78.6)
13	Bullying is classified under the physical hazard.	14 (20.0)	56 (80.0)	49 (70.0)	21 (30.0)
14	Risk is a combination of likelihood and severity.	59 (84.3)	11 (15.7)	63 (90.0)	7 (10.0)
15	Implement short-term measures to protect workers until permanent controls can be put in place	55 (78.6)	15 (21.4)	64 (91.4)	6 (8.6)
16	Control measured for low risk may not be necessary to be done.	6 (8.6)	64 (91.4)	13 (18.6)	57 (81.4)
17	Safety device must be installed when the hazard cannot be eliminated or reduce completely.	57 (81.4)	13 (18.6)	64 (91.4)	6 (8.6)
18	Elimination is the most practicable control to be used by the employer.	13 (18.6)	57 (81.4)	52 (74.3)	18 (25.7)
19	Putting a barrier to protect workers from hazards is one of the administrative controls.	17 (24.3)	53 (75.7)	42 (60.0)	28 (40.0)
20	Medium risk requires immediate action to be done to control the hazard.	4 (5.7)	66 (94.3)	25 (35.7)	45 (64.3)

The average mean (standard deviation, SD) scores for pre- and post-tests were 10.00 (1.69) and 13.91 (1.76) respectively. When the knowledge scores were analysed, it was found that there was a significant increase in the knowledge scores between the pre- and post-test stage. Table 4 shows the median scores for knowledge on HIRARC and statistical test value at pre- and post-test stage.

Table 4
The distribution of average knowledge on HIRARC scores among engineering students in a public university at pre- and post-test stage (n=70)

Median (IQR)		Z	p-value*
Knowledge before	**Knowledge after**		
10 (9-11)	14 (13-15)	-6.612	*0.0001

Statistical test: Wilcoxon-signed rank test **p-value significant at 0.05 level*

The raw scores were categorized into three categories of knowledge which were high, medium and low. Data obtained in this study clearly indicates that there was an increase of knowledge level after the trainings were delivered to the engineering students. For the pre-test, 70% (n=49) of the respondents were categorized into the medium knowledge group. However, after the interventions were given, a total of 45 (64.3%) of the respondents were categorized into high knowledge group and no respondent was categorized into the low knowledge category. Table 5 presents the distribution of knowledge on HIRARC categories at pre- and post-intervention stage among the respondents in this study.

Table 5
Knowledge level on HIRARC for the pre- and post-test among engineering students in a public university (n=70)

Level of knowledge	Pre-test	Post-test
	Frequency (%)	
High	0 (0.0%)	45 (64.3%)
Medium	49 (70.0%)	25 (35.7%)
Low	21 (30.0%)	0 (0.0%)

4. Discussion

OSH is a wide field that comprises various scopes such as risk assessments, emergency preparedness and response, incident investigations, operational control and others. For local undergraduate engineering curriculum, qualification body have provided the clear guide that OSH knowledge is a required body of knowledge [12]. HIRARC is a simple risk assessment tool and one of the most basic safety tools to help protect workers from risks of hazards at work. This study determined the effects of training on respondents' knowledge level among 70 respondents from three different engineering courses in a public university. This study reported a significant increase in knowledge level on risk assessment when the pre-test is compared with the post-test scores.

The OSH risk assessment training module delivered was intended to provide basic information on risk assessment and to provide knowledge. The training was delivered using simple words that can make the students easily understand the content of the training module. The use of multi-media pictures, videos, figures and within context-examples was incorporated to help students understand the information in the training module. One study in Spain reported to improve safety knowledge and commitment among students, safety program utilising expositive and demonstrative teaching methods were more suitable compared with other teaching methods [28].

Literature reported studies of OSH risk assessment training among undergraduates but these are limited and some examples are as follows: Ramzi and Abdulwahid [23] and Endroyo *et al*., [3]. Ramzi and Abdulwahid [23] reported the effects of training on basic principles of health and safety among undergraduates including engineering students and reported significant increases in knowledge and improvement in attitudes. Endroyo *et al*., [3] reported the need for industry-based OSH learning model which consist of contextual learning, cooperative learning and competency-based leaning to be used for undergraduates training. Training in OSH during educational years of engineering students is imperative because they are mostly young people who will enter the working sectors upon graduation. Training on safety must be done continuously as safety cover a very wide aspect in order to improve skills and performance of engineering students [29] and to reduce risk of workplace accidents [30].

The level of knowledge on OSH risk assessment in this study was generally moderate before the module delivery. As compared to other studies assessing OSH-related knowledge, one study on ergonomics among 247 engineering students in Malaysia found that knowledge level was moderate (mean=2.74; SD=1.21) [18] . In the present study, the students reported that they have learned about the concept of Hazard and Operability Study (HAZOP) which is a more complicated tool than HIRARC. HAZOP is a tool that identifies hazard and danger that might occur during the machine processing. Hanum *et al*., [31] performed a comparison between HIRARC and HAZOP methods and has identified that HIRARC is more dominant to the human factor while HAZOP focuses more on the equipment factor. It is suggested that there may be benefit if inclusion of OSH risk assessment is more thorough in the existing curriculum. Arisoy and Stojcevski [32] reported on how one university in Australia introduced Occupational Health and Safety and Risk Management practices from the onset of their engineering students' studies and continually reinforced OSH as a priority throughout the learning years.

In terms of OSH knowledge, some aspects could only be appreciated when students has gained industrial experience, in addition to traditional university method that could not address complex interactions in safety [33]. In this study, half of the respondents had already attended 10 weeks' worth of industrial placement in many different types of industries. Most of the respondents had to go for compulsory training before entering their industrial training hence this can serve as a crucial phase where OSH training could be incorporated. About 50% (n=35) of the respondents have attended training related to safety in construction industry by the Construction Industry Development Board (CIDB) which focus on facilitating the construction industry, Cardiopulmonary Resuscitation (CPR) training, Occupational Safety and Health seminar, blue card training for improving safety performance in the transportation industry and lastly, inert entry training that trains people on safety before going into inert space.

Overview from several guidebooks for bachelor in engineering degrees in Malaysia, it was found that OSH was not a core subject being offered. Instead, it is embedded as part of an existing subject in the curriculum. In the present study, the university's undergraduate study programme handbook indicated two core courses on OSH which was Safety and Risk Assessment and OSH in Processing Industries. Based on the course structure of engineering students from two public and one private universities in Malaysia, it was found that safety, hazard and risk assessment is not a specific subject being taught instead because safety is intertwined as a sub-topics in certain subjects allotted in the engineering courses. This is in line with the practices elsewhere. Institute of Occupational Safety and Health (IOSH) for example, a chartered body for safety and health professionals has identified the need to reassess the element of OSH in undergraduate engineering courses in the UK. As a results, modules which incorporates OSH elements were developed which materials in some sections being focused on specific engineering discipline and environment related to the learning needs of undergraduate engineers. This can overcome challenges which includes high existing demands and pressures on undergraduate time and lack of practical, active learning methods for OSH in a learning environment dominated by theoretical learning methods [34]. Alternatively, it has been suggested that training on OSH could be incorporated under the Life-Long Learning framework in universities and should be offered in a scheme of five thematic areas namely OSH management system, risk assessment, OSH in high-risk sectors, human-centred OSH in high-risk sectors and OSH through advanced technology [4].

Limitations of this study includes that there were no control or comparison group included as such there is no way to determine that the training provided was better than a standard course or topic in a subject. It is suggested that future study to be conducted with the inclusion of a control group to assess the risk assessment module and compare it with a standard course or topic on OSH risk assessment provided in curriculum.

5. Conclusion

Overall, this study found training delivered was linked with increased OSH risk assessment knowledge. There is the possibility for this module to be further refined and adapted in other educational institution to provide understanding and increase awareness on HIRARC importance that could be beneficial for engineering students before joining the work environment. Findings from this study suggests the potential for incorporation of HIRARC elements as sub-topics in engineering curriculum to equip engineers to-be with ability to eliminate hazards in the conceptual and designing phase of engineering work, thus reducing probability of accidents and ill-health from occurring in workplace. It is hoped that through materials developed in this study, it can help prepare students towards immersive safety culture mindset.

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