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The Effectiveness of Health and Safety Topics in an Engineering Course Syllabus

Zambri Harun[1,6]*, Ishak Arshad[2,6], Zahira Yaakob[3], Rosdiadee Nordin[4] and Hashimah Hashim[5]

[1]*Department of Mechanical and Materials Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia*
[2]*Department of Civil and Structural Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia*
[3]*Department of Chemical and Process Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia*
[4]*Department of Electrical Electronics and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia*
[5]*Faculty of Electrical Engineering, UiTM, 40450 Shah Alam, Selangor, Malaysia*
[6]*Centre for Engineering Education Research, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia*

ABSTRACT

Adherence to Health and Safety (H&S) is one of the required programme outcomes (PO) in all engineering programmes offered at the Faculty of Engineering and Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM). The Course Outcome (CO) is measured in the mandatory course, Engineering Ethics and Technological Advancement. A two-stage survey of students' understanding of H&S matters was carried out at FKAB. Students' responses in the first and second stages suggest that they feel they possess satisfactory understanding of H&S; however, this is not so. While this survey analysis concurs with previous studies on universities and gaps in industry expectation, these finding have to be addressed appropriately before students can enter the job market and practise H&S in the workplace as trained to do in university. The study also shows that an improved teaching method significantly increases students' understanding of H&S issues. A new syllabus for a course that addresses H&S issues has been implemented, together with the faculty-wide programme revision activity.

Keywords: Health and Safety (H&S), Personal Protective Equipment (PPE), ethics

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E-mail addresses:
zambri@ukm.edu.my, zambriharun@gmail.com (Zambri Harun),
ishar52@ukm.edu.my (Ishak Arshad),
zahira@ukm.edu.my (Zahira Yaakob),
adee@ukm.edu.my (Rosdiadee Nordin),
hashimah655@salam.uitm.edu.my (Hashimah Hashim)
* Corresponding author

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INTRODUCTION

Accidents due to health and safety (H&S) issues occur all year long, especially in developing countries, where massive projects are completed in fast-tracked modes and at low cost. As a developing country, Malaysia has its share of H&S issues. One shocking example of such issues is the tragic accident that resulted in the deaths of three foreign general workers at the Mass Railway Transit (MRT) construction site in Kota Damansara, Kuala Lumpur in 2014. Accidents due to H&S issues also occur in developed countries, for example, Singapore. An operator of an excavator died when the machinery toppled to the first floor of a building at a construction site near Thomson Road, Singapore, in June 2013 (The Straits Times, 2013). In addition, the Health and Safety Executive (HSE), a non-departmental public body in the UK sponsored by the Department for Work and Pensions published 133 worker deaths over the working year of 2013/14; which is equivalent to 0.44 deaths per 100,000 workers (Health and Safety Executive, 2014). In general, H&S issues are major problems and they can occur in any country. All parties involving construction workers, their employers and the public are responsible for H&S incidents; it is the culture around it that can lead to H&S accidents (Hale et al., 2010). Health and Safety Organisations (HSO) or Committees (HSC) are pivotal in ensuring safety efforts and should therefore be the natural starting place for a change to safety-first culture. Results of studies indicate a marked improvement in HSO performance, interaction patterns concerning safety, safety culture indicators and a change in the trend of injury rates (Nielsen, 2014); however, the theoretical framework for safety culture is generally underdeveloped and the link to research on organisational culture has been weak or even non-existing (Choudhry et al., 2007).

Health and safety issues do not only cause injuries and fatalities, they can also incur big losses and impact. The fatal accident at the MRT site in Malaysia referred to earlier caused the issuance of a stop-work order. The Chief Executive Officer of MRT Corp, the contractor for the MRT line, voluntarily offered to resign (Lee and Hamudin, 2014). An initial investigation by the Department of Occupational Safety and Health (DOSH), a department under the Ministry of Human Resources overseeing H&S issues, revealed that there were no engineers at the site during the installation of the parapet wall of the Sungai Buloh-Kajang (SBK) line of the Mass Rapid Transit (MRT); this breach in standard operating procedure (SOP) led to non-compliant acts that resulted eventually in a 650-tonne span becoming dislodged and falling to the ground.

(a)

(b)

Figure 1(a) & (b). MRT accident site, Kota Damansara (Lee and Hamudin, 2014).

The longer term and much bigger impact of such an incident is the public's loss of confidence in MRT construction projects and the costly delay of multi-billion *ringgit* investments. A one-day site delay means a day's delay in overall completion. The scale of an MRT project is enormous, so such a delay causes not only a big loss to the company, sub-contractors and suppliers, but also to the country and the public. Figure 1(a) shows government officials cordoning off the site and Figure 1(b) provides an aerial view of the area in which the accident took place. Harun et al. (2013a) showed that when accidents occurred due to non-compliance of H&S regulations, not only did they cause the loss of lives and damage to property, they also diverted government focus from nation building.

There are many local construction companies bidding for works internationally in emerging economies such as Brazil, India, Turkey and Bangladesh (Chuing & Abdul-Rahman, 2011). These companies might carry negative traits even though they might not be involved in the construction of any MRT lines. The negative perception might cost them the chance of winning an international job. Malaysis might not achieve its vision of becoming a developed country by 2020 if similar issues keep occurring; the government will lose its focus on development as its attention is diverted towards unnecessary issues, as mentioned by Harun et al. (2013a). On the other hand, if companies manage to keep an excellent track record, such as highway concessionaire UEM, which completed the 116.8km Cikopo-Palimanan infrastructure in Indonesia, confidence in local companies builds up. For this reason, this paper sought to understand the effectiveness of H&S topics provided in a mandatory course offered in UKM, Engineering Ethics and Technological Advancement (course code KKKF3283), which is compulsory for all third-year undergraduate engineering students.

METHODOLOGY

A two-stage survey was conducted among students who were enrolled in the Engineering Ethics and Technological Advancement. The first stage was conducted before the respondents were taught H&S topics and the second stage after they had been exposed to the H&S elements in the lecture. Since the size of the student enrolment was large, an Internet-based questionnaire was distributed electronically as this was believed to be better able to cater for the large volume of questions and answers. The questionnaires were divided into four categories. In the first category, students were asked basic questions i.e. about their background. This was also to familiarise the students with the electronic system.

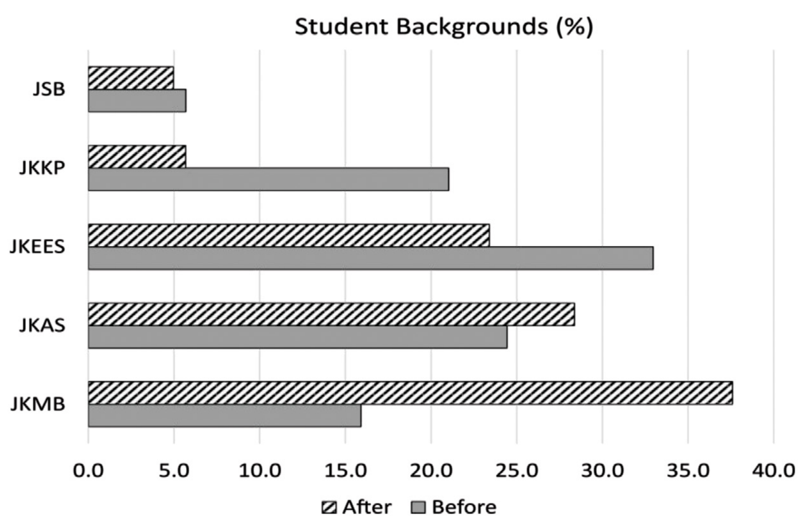

Figure 2. Percentage of student background by department showing figures before and after H&S topics were taught.

Figure 2 shows students from all four engineering departments as well as from the Department of Architecture (*Jabatan Seni Bina*, JSB) who participated in the survey. The patterned horizontal columns indicate the percentage (%) of student participation after H&S topics were taught according to department. The grey columns indicate student participation before the lectures. The Department of Electrical, Electronics and Computer System (*Jabatan Kejuruteraan Elektrik dan Elektronik*, JKEES) made up the most number of students i.e. 33.0% before the H&S lectures. This was followed by the Department of Civil and Structural Engineering (*Jabatan Kejuruteraan Awam dan Sivil*, JKAS) (24.4%), the Department of Chemical and Process Engineering (*Jabatan Kejuruteraan Kimia dan Proses*, JKKP) (21.0%), the Department of Mechanical and Materials Engineering (*Jabatan Kejuruteraan Mekanik dan Bahan*, JKMB) (15.9%) and the Department of Architecture (5.7%). Quite a large percentage of students participated in the first-stage survey i.e. 176 students out of totally 231 students, equivalent to 76.2%. About 61% of the students participated in the second-stage survey. The details of student involvement are shown in Table 1.

Table 1
Student Participation

	Before H&S Lectures	After H&S Lectures
Total number of students in KF3283 (persons)	231	231
Student participation in the survey (persons)	176	141
Percentage of participation (%)	76.2	61.0

There was a variety of student activities that were related to H&S issues. These activities were categorised into the following: (i) Perodua Eco-Challenge or PEC; (ii) Shell Eco-Marathon (SEM); (iii) Proton Green Mobility Challenge (PGMC); (iv) ChemECAR; and (v) concrete-mixing & site visit and several other activities. This information is summarised in Figure 3. Wearing Personal Protective Equipment (PPE) was required most of the time for all the activities. On the other hand, activities categorised under 'Others' did not necessarily require participants to wear any PPE. For example, in robotic and recycling programmes, the participants were not required to wear any PPE.

In Figure 3, for the first-stage survey, students who chose 'no involvement' made up 31.3% of respondents while students who participated in the Perodua Eco-Challenge or PEC made up 5.7% of the survey population; those who took part in the Shell Eco-Marathon (SEM), 11.4%; Proton Green Mobility Challenge (PGMC), 4%; ChemECAR, 13.1%; and concrete-mixing/site visit, 6.3%. Students who participated in other activities made up 28.4% of the sample. The ratio of students who were involved in activities against those who were not is approximately 2.1:1 (i.e. (100-31.3) / 31.3). This shows that the majority of the students were active in extra-curricular activities. A leap in student participation in SEM indicated that the start of this (SEM) project was some time between the two surveys.

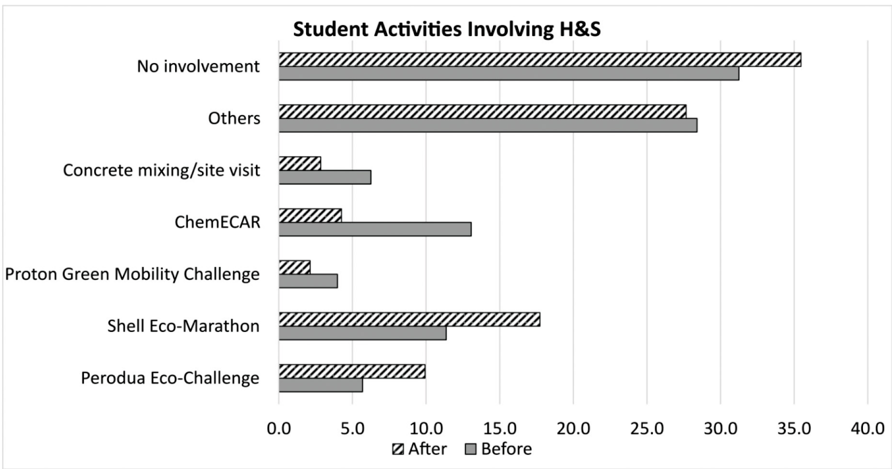

Figure 3. Students who participated in activities in which adherence to safety rules are important before and after H&S topics were taught.

The survey was conducted using an Internet-based programme. It is user friendly and took less than five minutes to complete. The invitations to complete the survey were sent by email and *iFolio*, a full-fledged student electronic e-learning system. The survey was conducted on voluntary basis. The sample was taken from the Engineering Ethics and Technological Advancement course. A five-point Likert scale was used for the questionnaires, in which 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. Some of the questions asked regarding H&S were subjective in nature such as "understanding H&S issues…"; inference was required to measure beliefs related to common measurement techniques. Employing a Likert scale in this study might not have been the best approach. To reduce this lack of fit, a guideline for answering the questionnaires was considered (Glendon et. al., 2006).

RESULTS

The first response out of the four results to be discussed here is related to students' understanding of PPE.

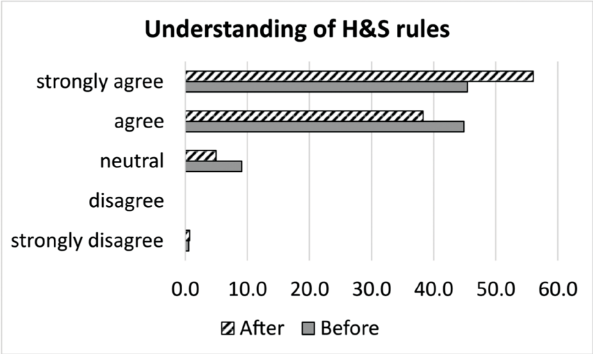

Figure 4. Understanding of health and safety rules before and after H&S topics were taught.

Figure 4 shows students' understanding of H&S rules. The total percentage of strongly agree and agree are 90.3% and 94.3%, respectively for before and after the H&S lectures were given.

Figure 5 shows the response to the question on influence of H&S rules in respondents' everyday lives. A whopping 96.6% and 97.9% of the students agreed that H&S aspects had an influence on their lives before and after they attended the H&S lectures, respectively. It is assumed that students do not only observe H&S rules in the laboratory or in workshops at university, but also practise similar rules at home. These could be, for example, when fixing their motorcycles (typical mode of transportation among students) etc. In UKM, laboratories practise strict H&S rules. Accidents related to H&S are rarely reported; therefore, the responses to this question was within expectation.

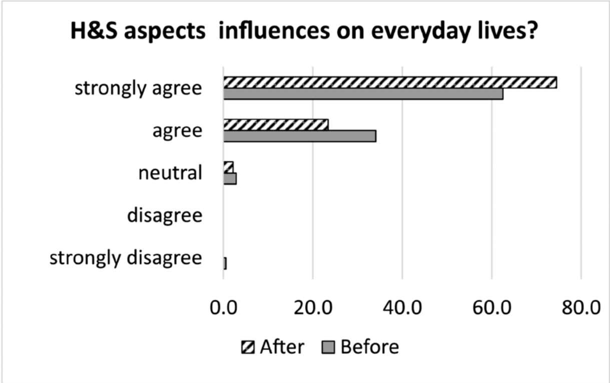

Figure 5. Response to the question relating health and safety aspects to everyday life practices before and after H&S topics were taught.

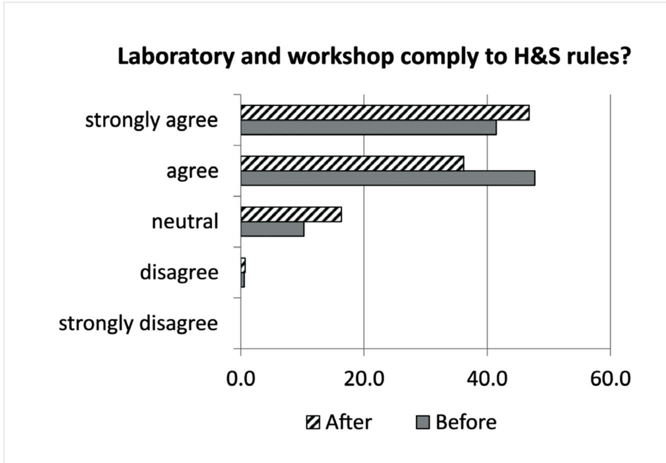

Figure 6. Response to the question on compliance with H&S rules in the laboratory and during workshops before and after H&S topics were taught.

Figure 6 shows the response to the question on compliance with H&S rules in the laboratory and during workshops before and after H&S topics were taught. About 89.2% and 83% responded positively, respectively, for before and after H&S lectures. Students who chose neutral for this question increased by 6% from 10.2% to 16.3%. It is interesting to note that the 6%, who originally agreed that laboratories and workshops observed H&S rules now felt unsure. There might be certain elements that the student had learnt during the lectures that might have influenced their perception and understanding of health and safety. The strong positive responses of 89.2% and 83% to the question on labarotory and workshop compliance seem to be on the high end as safety culture is generally underdeveloped in many places of work (Nielsen, 2014; Choudhry et al., 2007).

Figure 7 shows students' responses on their understanding of PPE. It is quite interesting to observe that, in general, there was a big jump from students who strongly agreed and agreed, 55.3% after the lecture against 30.7% before the lectures on H&S issues. This result means that close to one fourth (55.3% - 30.7% = 24.6%) of the participants thought that they knew about H&S issues, but in fact, they did not. The big numbers of those who did not understand PPE and those who were not sure (approximately one third of the students) signify that their positive responses recorded in Figure 4 to Figure 6 might have been compromised by some of the participants, whose knowledge was limited to H&S matters. PPE is a must-know item in H&S, and not knowing the meaning of it leads to total disregard for its use in the laboratory and workshop.

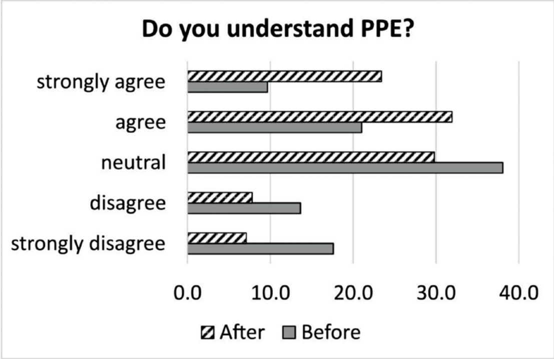

Figure 7. Students' understanding of PPE before and after H&S topics were taught.

That a large number of the students still did not know what PPE was after the lecture is worrisome for lecturers. About 7.1% strong disagreed and 7.8% disagreed. These students will enter the job market thinking that they understand H&S when in fact, they do not. Remedial action such as more elaborate explanation and more examples should be given in lectures. This study also agrees with previous findings that showed a gap between employer and university expectations (Zaharim et al., 2009) of students. Students and universities have the perception that certain important topics have been sufficiently covered in the programme, but the industry feels otherwise.

There is a great need to arrange for H&S special lecture sessions to address students' misunderstanding of H&S. As a matter of fact, this issue was realised at the start of the year, when the Engineering Accreditation Council (EAC) audited the Department of Mechanical and Materials (Harun et al., 2013b). It was found that the PO on H&S was not sufficiently measured in both engineering programmes offered. The authors also realised that quite a large ratio of students were active in curricular activities requiring sufficient knowledge of H&S i.e. 2.1:1 as shown in Figure 3, and therefore, immediate action was needed to avoid risk of accidents.

New curriculum syllabi for all engineering programmes in UKM for the 2015-2016 session have been developed starting from 2014. Information regarding student performance based on their grades, their Programme Outcome (PO) performance, industrial expectations through the industrial advisory panels (IAP) and ongoing quality improvement actions were gathered. The development and review for these engineering programmes was headed by the Deputy Dean (Undergraduates & Alumni). Generally, the structure for all revised programmes is based on Fig.8. While the structure shown is for the Mechanical Engineering programme, all other engineering programmes follow the same framework, especially for the 'Compulsory University and Citra Courses' and 'Mathematics Courses'. Note that the course KKKF3283, 'Engineering Ethics and Technological Advancement' where the PO for H&S is measured, and whose students were involved in these surveys, is in Semester 5 in the currently approved programmes. This course is written in red in Figure 8. This course is categorised in the university-compulsory course.

CATEGORY	YEAR 1		YEAR 2		YEAR 3		INTER-SESSION	YEAR 4	
	SEM 1	SEM 2	SEM 3	SEM 4	SEM 5	SEM 6	Industrial Training	SEM 7	SEM 8
Compulsory University and Citra Courses		**LMCW**	**LMCW**	**LMCW**	**KKKF3283** Eng. Ethics & Techn. Advancement			**LMCE** Speech Comm., Presn. Skills, Professional Written Comm.	
	LMCE Foundation English	**LMCE** Academic Communication I	**LMCK**	**KKKQ** Eng. Statistics	**LMCE** English for Eng. and Architecture			**KKKM** Eng. Economy	
	LMCE Academic Communication I				**LMCR** free flow				
	KKKM Engineering Graphic Designs								
Matematics courses		**KKKQ** Eng. Mathematics II	**KKKQ** Eng. Mathematics III						
Core Engineering Courses	**KKKQ** Eng. Mathematics I	**KKKM** Eng. Statics	**KKKM** Thermo. and Heat Transfers						
	KKKM Science and Mtrls. Eng.								
Culminating Course	**KKKM**	**KKKM**	**KKKM**	**KKKM**	**KKKM**	**KKKM**	**KKKM** Ind. Training	**KKKM**	
		KKKM	**KKKM**	**KKKM**		**KKKM**		**KKKM**	
			KKKM	**KKKM**		**KKKM**		**KKKM**	
				KKKM		**KKKM**			
Culminating Course					**KKKM** Integrated project	**KKKM** Fluid dynamics		**KKKM** Eng. Design Project I	**KKKM** Final Year Thesis
					KKKM Thermal Systems	**KKKM** Quality Management			**KKKM** Eng. Design Project II
					KKKM Mechanical component Anls.				
Elective Courses								**KKKM**	**KKKM**
									KKKM
									KKKM

Figure 8. Typical engineering programme curriculum structure.

There are a few other courses that measure H&S performance; however, this course depends on the respective programme requirements. Therefore, it is easier to discuss the course KKKF3283 only. The new curriculum structure allows students to get involved in extra-curricular activities that require knowledge of H&S matters as shown in Figure 3 and at the same time to enrol in KKKF3283. The extra-curricular activities usually involve year-three students. This way, students get the benefit of practising their in-class knowledge.

The course syllabus for KKKF3283 is improved in the faculty-wide engineering programmes revision. To improve the delivery of H&S requirements, one of the Course Outcomes (CO) is rewritten specifically i.e.:

Ability to make engineering decisions which take into consideration cultural differences, health and safety, technology transfer and infrastructure.

Below is the Course Outcome for which the Programme Outcome related to H&S is measured:

Ability to apply reasoning informed by contextual knowledge to assess societal, health safety, legal and cultural issues and the consequence responsibilities relevant to professional engineering practice.

The new syllabus contains detailed requirements for H&S, specific PPE requirements, consequences, local acts and two-way discussions in the lecture hall. There is no change to the measurement methods of this CO and consequently PO, which is through examination questions and final-report presentations. The improved understanding among students through their responses shown in Figure 4 to Figure 7 is used as the basis for syllabus change.

CONCLUSION

Health and safety aspects at university are important elements to ensure not only that there are no injuries and accidents, but also to promote a comfortable working environment for future engineers. The latter helps students achieve better results in their study or research. We have identified that students understood and practised H&S rules appropriately. This was evident from their highly positive scores in the questionnaires (in most cases, more than 80%). Despite a jump in the number of students who understood the word PPE, the relatively large number of students who did not understand the definition of PPE calls for immediate remedial action. For future planning, the Engineering Ethics and Technological Advancement course will add more elements of H&S to address this issue.

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