Occupational Health and Safety: An expected learning outcome of Civil Engineering Graduates

Vanissorn Vimonsatit
Department of Civil Engineering, Curtin University, Perth, Australia
v.vimonsatit@curtin.edu.au

Ommid Nikraz
Department of Civil Engineering, Curtin University, Perth, Australia
Ommid.nikraz@postgrad.curtin.edu.au

***Abstract**: The high number of fatalities in the construction industry shows the needs for improvement in Occupational Health and Safety (OHS) measures. Civil Engineers, being regarded as a member of 'top tier' management in construction projects, are prone to have knowledge of OHS procedures and regulations. However, OHS training is not always integrated in engineering education. This paper identifies the need to incorporate the teaching and learning of OHS in Civil Engineering education, and proposes that the knowledge of OHS is an expected learning outcome of Civil Engineering graduates. Since 2010, The Department of Civil Engineering at Curtin University has recently incorporated OHS topics in a construction management unit of its undergraduate course. To test OHS awareness, pre- and post-lecture questions relating to the basic knowledge of OHS in construction practices, laws and legislations have been distributed to the students in a class of final year students. The answers to the pre-lecture questions are used as the key indication of the weakness and strength in the knowledge and the perception of the students regarding OHS in construction. The lecturer can also use this information to deliver the lectures more effectively towards the expected learning outcome of the topics. The answers to the post-lecture questions provide excellent feedback on the teaching and learning effectiveness. This paper will present the analysis of the answers to the pre- and post-lecture questions based on the contents that are deemed necessary and important for the students to possess the basic knowledge, attributes and skills in OHS. The paper will also present how OHS, as an expected learning outcome of Civil Engineering graduates,will improve the relevance of engineering education for industrial practices.*

Introduction

The construction industry is the major employer of Civil Engineers. Although the Construction industry places a higher priority upon its Occupational Health and Safety (OHS) measures, it consistently has greater fatalities compared with other industries. An in depth comparison with the manufacturing industry indicates that the unique work practices within the construction industry make it vulnerable to poor OHS outcomes (Bethell and Vimonsatit 2011). Research conducted by Dingsdag, Biggs and Sheahan (2008), demonstrates that OHS education and training is a persistent theme that workers believe will improve safety within a workplace. Given the low prevalence of training and education in the construction industry, Dingsdag et al (2008) found it unsurprising that the respondents in their study gave 'OHS training & Education' a high ranking as a requirement for the critical safety role holders as well as themselves. Their studies respondents were not referring to a lack of quality of available training, but a generic lack of OHS education at a tertiary level. A concern is that the tertiary education received by managing directors through to middle managers has little or no OHS component. Typically these executives are engineering, quantity surveying, project management and architecture professionals who largely rely on OHS managers and professionals to provide the necessary safety expertise.

Australia's construction industry has achieved significant improvement in their health and safety performance in recent years. It is however still one of the most dangerous workplaces in the country (George, 2007). The aim of the construction safety management is to target 'zero accident' policy. Civil Engineers are involved in all aspects of a project life cycle. From design to construction and the eventual demolition, civil engineers will guide the work practices to complete the task. With this supervisory role, they are directly and indirectly responsible for the health and welfare of onsite staff. Civil Engineers are therefore expected to have a good knowledge of OHS.

At Curtin University, much emphasis has been placed to promote awareness of OHS among its students and staff. The Department of Civil Engineering (CE) has therefore incorporated OHS topics into the teaching and learning of some core units in the construction management component of its CE undergraduate course since the year 2010, and has been formalised in 2011.

This paper presents the need for promoting OHS awareness among CE students, and that OHS knowledge should be an expected learning outcome of CE graduates. In the following sections, this need will be justified and highlighted. A model for promoting OHS awareness process and the incorporation of this process into formal education will be described. To assess the effectiveness of the process, students are tested on their basic OHS knowledge and the outcomes will be presented.

Needs for Promoting Occupational Health and Safety Awareness

A construction workplace is usually associated with high risk of work-related injuries and fatal accidents. In the year 2008-2009, 177 people lost their life in workplace fatalities in Australia, 31 of which were in the construction industry (Safe Work Australia 2009) - an increase of 14% from the previous year.

Research by Toner (2000) found that there was a marked reduction in construction firms' investment in training over the 1990s. This reduction was linked to industrial re-structuring and reduction in firm size. All of the employment growth over this period occurred in businesses with less than five employees. Employment in larger firms actually declined, with employment in firms with 20 or more employees falling by more than 50 per cent. Even by 2002, the construction industry still had a structured training provision percentage well below the general industry standard for training its employees (Australian Bureau of Statistics, 2006).

In order to increase OHS awareness, previous studies (Bethea 1992; Bryan 1999) indicate that OHS content should be included in engineering curricula. The next question is to what extent that the students should be trained. A construction workplace is transient and has high turnover of employees on site. To ensure safe work environment in a job site, OHS induction and training should be provided, at least, in two stages. One is the immediate induction which is to be provided as soon as a person is employed. The immediate induction should cover general knowledge of OHS requirement and make known the duty of care and responsibility of the person on the wellness of themselves and their peers in the workplace. The other stage of the induction and training is to be more specific to a job site and is appropriately provided when there is a movement in work placement. Due to the complexity and levels of details to suit any specific job site requirement, the objective in the teaching and learning of OHS component, as outlined in this paper, is to provide the generic knowledge of OHS, and in the process, aims at promoting the safety awareness among its CE future graduates. More specific learning outcomes of the subject are described under the section of Occupational Health and Safety Awareness Process.

Incorporating Occupational Health and Safety in Formal Education

A way to integrate OHS in the engineering course is by embedding it in an existing coursework (Al-Abdeli and Bullen 2005). An outcome from the 2010 curricula development review at Curtin University led to synthesising two core units, namely, CE Practices and Procedures (Whyte 2010) and CE Quality Control (Vimonsatit 2010). The new Unit was named CE Practices, Quality and Legislation, in which the legislation component was emphasised and reflected in the Unit title (Whyte 2011). The OHS topics had elements of knowledge relevant to the legislative component and therefore were integrated in this Unit.

Since the past decades, innovations in undergraduate CE curricula worldwide have been stimulated by several aspects. Pauschke and Ingraffea (1996) defined eight emerging themes in the reform movement in CE education. One of which was to put strong emphases in design courses on multidisciplinary approaches with actual industry projects and practitioner input/evaluation. Incorporating OHS topics in CE education was considered part of this emerging theme. It was expected that the OHS knowledge would promote the OHS awareness, as well as broaden the students' perspectives on the career opportunities in the engineering profession. To effectively deliver the industrial-relevant OHS knowledge the second author, who was an experienced practitioner, was invited as a special guest lecturer to cover the OHS topics of the Unit.

Occupational Health and Safety Awareness Process

This section outlines the process which defines essential steps in promoting OHS awareness as part of teaching and learning of OHS topics. The term awareness is used, rather than knowledge, as it is believed the safety awareness is not achieved purely by learning stereotype classes. It needs to be nurtured within the organisation, i.e., to develop and maintain the safety culture which could begin from raising the safety awareness in each individual at all levels of the organisation.

Promoting OHS awareness is therefore used as the key strategy in developing the teaching and learning process. This process is adapted from a design process by Bowman and Farr (2000), who has successfully prepared the students for engineering leadership challenges that combine knowledge with technology in pursuit of solving problems. The proposed process is a prototype that will evolve through the quality monitoring and reviewing process. It contains the following steps:

1. Assess the knowledge to be acquired by the students which can be done based on the expectation of the future employer in the industry.
2. Identify the current knowledge and awareness of the students, in terms of weaknesses and strengths.
3. Design the teaching and learning strategies, objectives and suitable technical components.
4. Evaluate the effectiveness of the Design plan and review.
5. Make necessary adjustments
6. Deliver and evaluate the effectiveness of the teaching and learning

Step 1 The review of the literature shows that civil engineers and designers were found lacking the key issues concerning OHS processes and are traditionally not taught safety in their academic courses, as a result, they may think that safety is not their responsibility.

However, both government and industry have realised the importance of OHS, embedded in civil engineering degrees. Globally this matter has become a new challenge on how to incorporate OHS in all civil engineering courses and expectations from new graduates commencing work such as in the project management area (Badri et al 2011). Some of the knowledge required from new graduates is briefly outlined below:

- Demonstrate ability to prepare an OHS safety plan and programs through the four stages of the project life cycle (planning, design, construction and post construction);
- Ability to demonstrate hazards identification, risk assessment and planning control measures;
- Knowledge of design safety legislations, OHS legislative requirements, Australian standards, responsibilities (e.g. employer, employee, manufacturers, workers compensation), where to find OHS information (e.g. Safe Work Australia) and new technologies;
- Environmental issues;
- Knowledge about health and attitude of the workforce (e.g. young, new, aged). Ethnicity and language barriers are also to be considered;
- Clear understanding of physical and chemical hazards and their effect on the workforce;
- To make construction sites safer, issues of drug and alcohol impairment should be taken seriously and dealt with accordingly.

Step 2 is to identify the current knowledge and awareness of the students in terms of weakness and strengths. This is done by distributing a set of questions to students prior to teaching. The questions aim at assessing common knowledge about OHS. Students were asked to self-assess their own knowledge and identify the expectation from learning this topic. The knowledge on regulatory bodies and legislations was also assessed. The rest of the questions focussed on students' perception on the level of safety in the construction industry, risk and hazard management, and the OHS training expected to be provided by their future employers. The students were also asked to think critically and creatively on how to improve the OHS measures in the construction industry.

Step 3 is the Design plan, which is to devise the teaching and learning strategies, objectives and suitable technical components of OHS. Based on Step 2, the teaching and learning strategies can be attuned to enhance the students learning. The objectives and technical components are derived based on the information identified in Step 1. More specific learning outcomes are described under the assessment section of this paper

Step 4 is to evaluate the effectiveness of the Design plan in Step 3, and then review. At this stage, the evaluation is done in accordance with the teaching and learning objectives set out in Step 3.

Step 5 is the outcome of Step 4, which is to determine whether any actions need to be taken to improve the teaching and learning outcomes.

Step 6 is the final phase of teaching and learning. Delivery the body of knowledge to the students is the first step. Then, to evaluate the effectiveness of teaching and learning, the same set of questions given prior to learning is used to assess the students' level of understanding immediately after learning.

The pre- and post- lecture assessments on OHS knowledge are used as the indicatives in the OHS awareness process, which are part of the teaching and learning strategies. The results of the pre- and post-lecture assessments will be presented next.

Pre-Lecture Results

The OHS topics were delivered in two of three-hour sessions. A set of questions was prepared to assess the students' knowledge of OHS before the first lecture and after the second lecture. The questions were mixtures of Yes/No type and descriptive type. The students attended the first and second lectures were 52 and 17, respectively. The pre- and post-lectures questions were only directed to the students who attended the lectures.

As described in Step 2 of the OHS awareness process, the first part of the questions was to allow the students to self-assess their own knowledge. Out of the 52 students participated in the pre-lecture questionnaire, 50% claimed to have basic knowledge, which meant new to the role and had limited experience with OHS issues, 46% had already some experiences but opened to new ideas, while only 3.8% claimed to have advanced knowledge.

When asked about the work health and safety law and enforcing body, such as Safe Work Australia, over 50% was aware of the existence of the law and the enforcing body. However, the majority (about 90%) could not provide any further details about such law and organisation. It is therefore unsurprising that 94% response to no knowledge of any Code of Practice relating to OHS training.

On the perception of safety, the students were asked to rate the level of OHS in the construction industry. It was interesting to find that the majority rated the industry to be "safe enough" (58%) and "very safe" (25%), while 14% gave "unsure" answer, and only 2% rated "unsafe".

With the descriptive type of the questions, students were asked to critically think and identify their expectations of the OHS training from the lectures and the future employers. The response to these questions was quite satisfactory, 81% expected employer to provide OHS training such as, company induction, site specific induction, first aids, and safety procedures. Some responses also identified that workplace hazards be identified and how to work safely be explained in the training.

It is understood that there is no any amount of efforts sufficient enough to eliminate hazards and accidents. OHS measures are therefore fundamentally associated with risk and hazard management.

The students were therefore asked to describe their understanding of the two terms. Over 80% was able to describe generically the meaning of the terms and about 60% was able to describe some brief details of the management process.

The students were also asked to creatively think of the safety measures that would help improve the OHS in the construction industry. Some of the answers to this question were remarkable, as follows: "eliminate the buried under paperwork/documents/manuals", "more involvement at worker level", "somehow more red tape than what is already in place", "better communication among the employees without being criticised or referred to non-conformance notice", "lead by example and promote risk awareness nature in the workplace", "provide routine induction and safety officer", and "stricter penalties for companies that do not comply with the laws". Of all these responses, about 30% pointed out that greater education and recurrent training would help to improve OHS in the industry. This response was consistent with a research by Mottram (2005) who noted that staff showed a greater awareness of new initiatives, legislation and technology; and individuals think about safety at an earlier stage, and plan works to minimize risks, as a result of the training.

Post-Lecture Results

At the end of the second lecture, 17 students who attended the lecture were given the same set of questions as the pre-lecture set. The response to the self-assessment on OHS knowledge was 33% basic, 53% intermediate, and 13% advanced knowledge. There was a slight increase in the knowledge gained, albeit percentage wise, when compared to the pre-lecture response. Other responses were also as expected. The knowledge of the OHS laws and enforcing body was increased to 80%. The perception on the level of safety in the construction industry was also increased from 25% to 33%. The knowledge of the existing code of practice relating to training was also increased from 6% to 50%. On the risk and hazard management, the response was very satisfactory as over 90% could better define the terms in a way that was more specific with a management process. Similarly on the question to provide ideas for the measures to improve OHS in the construction industry, over 80% suggested education and training as the measures. This outcome was, however, inconclusive as it was possible that the post-lecture responses group was the majority who provided the same answer to the pre-lecture questions. A more formal assessment would better define the students learning outcomes.

Assessments

To enhance the students learning, a formal assessment is often necessary. In this Unit, there were three main assessment components: a project-based assignment, an oral presentation and a final examination at the end of the semester. Based on these components, the learning outcome of OHS topics can be assessed to match with Curtin's graduate attributes 1 to 4 and 9, as follows:

A project-based assignment requires the students to demonstrate the ability to apply the knowledge of OHS to a specific construction project. More specifically, the students were required to develop a safety management plan for a highway extension project. In doing so, a quantitative research is required to collect the information from several sources, then evaluate, interpret, and recommend for the assigned project. The project is a group assignment, which is common for a final year unit, so as to promote effective written and oral communication, strong interpersonal skills and professional skills among their peers. The oral presentation also enhances the expected learning outcome towards these graduate attributes.

Group work is not ideal in assessing individual competencies. Assessing students on their OHS knowledge should therefore be part of the final examination questions. This realisation is consistent with the Department's intention to specify OHS as an expected learning outcome of CE graduates. The final examination will indicate the level of understanding among the students individually and the whole cohort.

Table 1 describes the marking strategy used to assess the students' level of understanding of the OHS management process. The students learning outcome and the link to generic graduate attributes are listed in Tables 2 and 3, respectively.

Table 1 Marking Scheme in % of OHS component

Marking Guide	Work Details
Demonstrate ability to prepare an OHS safety plan and programs through the four stages of the project life cycle 50%	1. planning 2. design 3. construction 4. post construction
Demonstrate knowledge of hazards identification, risk assessment and planning control measures 20%	5. hazards identification 6. risk assessment and 7. planning control measures 8. Clear understanding of physical and chemical hazards and their effect on the workforce;
Demonstrate knowledge of design safety legislations, OHS legislative requirements, Australian standards, responsibilities 10%	9. outline design safety legislations, 10. outline OHS legislative requirements 11. provide sufficient references to relevant Australian standards 12. define responsibilities (e.g. employer, employee, manufacturers, workers compensation) 13. provide sufficient references to OHS information (e.g. Safe Work Australia) and new technologies
Demonstrate knowledge of Environmental issues 10%	14. outline environmental protection process 15. outline compliance plan
Other related knowledge to make construction sites safer 10%	16. recognise health and attitude of the workforce (e.g. young, new, aged). 17. Understand ethnicity and language barriers 18. Know issues of drug and alcohol impairment

Table 2 Learning Outcome

Learning Outcome	% passing	Average results
Know the relevant authorities and regulatory bodies	>80%	Post-lecture test
Understand OHS process in the construction industry	>80%	Oral presentation
Recognise the fundamentals of risk and hazard management	>90%	Assignment, Post-lecture test
Apply knowledge to develop an OHS management plan for a construction project.	>80%	Assignment, Final Exam

Table 3 Graduate Attributes

Graduate Attributes	Assessment Method Linking Graduate Attributes
Ability to apply knowledge of basic science and engineering fundamentals	Assignment, Oral Presentation, Examination
Demonstrate critical and creative thinking	Assignment, Oral Presentation, Examination
information literacy – understanding of problem identification, formulation and solution	Assignment, Examination
effective communication skills –ability to work collaboratively	Assignment, Oral Presentation
professional skills – understanding of professionalism, ethical responsibilities and integrity	Assignment, Oral Presentation

Conclusions

The paper proposes OHS as an expected learning outcome of Civil Engineering graduates. OHS education and training are regards as key measures to improve OHS outcomes of the construction industry. It is also expected that the OHS knowledge gained through CE education will provide a

strong foundation to CE graduates in pursuing their career with more safety awareness, which is a necessary first step towards better safety outcomes.

In this paper a process for incorporating OHS as a new teaching and learning subject has been developed. This process can be used as a prototype when incorporating any new subject areas.

To ensure that the knowledge of OHS is achieved as an expected learning outcome, three formal assessment components were embedded as the Unit requirement. Through these assessments, the students were able to demonstrate their graduate attributes in their application of knowledge, critical and creative thinking, information literacy, effective communication skills, and professional skills.

Acknowledgements

The authors wish to thank the reviewers for their comments on the first draft of the paper.

References

Al-Abdeli, Y. M. and Bullen F. (2005), "A Problem Based/Experimental Learning Approach to Teaching Maintenance Engineering", *Proceedings of the 2005 ASEE/AaeE 4th Global Colloquium on Engineering Education,* Paper 42.

Australian Bureauof Statistics(2006)E*mployer Training Expenditure and Practices, Australia, 2001-02.*Australian Bureau of Statistics. Assessed at http://www.abs.gov.au/Ausstats/abs@.nsf/Lookup/ 00D5FE2BE9FCA5B1CA256CFB008083B0 on 14 May 2009

Badri, A., et al. (2011) Occupational health and safety risks: Towards the integration into project management. *Safety Sci.* (2011),doi:10.1016/j.ssci.2011.08.008, in press.

Bethea, R. M., "Engineers Encourage Universities to Emphasize Safety in Curriculum", *Occupational Health and Safety*, Vol. 61, 1992, pp. 22-25.

Bethell, H. &Vimonsatit, V. (2011), Occupational Health and Safety in the Construction Industry: A review of Work Practices, In S.O. Cheung, S. Yazdani, N. Ghafoori& A. Singh (Eds.), *Proceedings of Modern Methods and Advances in Structural Engineering and Construction* (pp. 479-484), Zurich, Switzerland.

Bowman, B.A.& Farr, J.V. (2000), Embedding Leadership in Civil Engineering Education, *Journal of Professional Issues in Engineering Education and Practice*, ASCE, January, p. 16-20.

Bryan, L. A., "Educating Engineers on Safety", *J. Management in Engineering*, Vol. 15, 1999, pp. 30-33.

Dingsdag, D., Biggs, H.&Sheahan, V. (2008), Understanding and defining OH&S competency for construction site positions: Worker perceptions,*Safety Science, 2008*. 46(4): p. 619-633.

George, D. (2007), 'New Code for Safety in Construction', *Engineers Australia*, 79(8), p. 38.

Mottram, C. (2005),*Training hones the safety culture at BirseCivils Ltd*., Human Resource Management International Digest, 13, 14-16.

Pauschke and Ingraffea (1996) Recent Innovations in Undergraduate Civil Engineering Curriculums, *Journal of Professional Issues in Engineering Education and Practice*, ASCE, July, p. 123-133.

SAFE WORK AUSTRALIA (2009),*Notified Fatalities Statistical Report 2008-09*. Commonwealth of Australia.

Teaching and Learning at Curtin (2010), *Office of Teaching and Learning*, CURTIN University, Perth, Australia.

Toner, P. (2000), Changes in industrial structure in the Australian construction industry: causes and implications. Economic and Labour Relations Review, 11, 291-307.

Vimonsatit, V. (2010), *Unit Outline: Civil Engineering Quality Control 464*, Department of Civil Engineering, School of Civil and Mechanical Engineering, Curtin University.

Whyte, A. (2011), *Unit Outline: Civil Engineering Practices, Quality and Legislation 464*, Department of Civil Engineering, School of Civil and Mechanical Engineering, Curtin University.

Copyright statement