Designer's Safety Curricula for Undergraduate Students

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Abstract

DfCS is an approach in minimizing and reducing project risk that can be described as designing for constructability. The designers have the responsibility towards the workforce by considering safety in their design where it is practicable. Sadly, they are not well-trained and educated enough to apply this method in practice. Their formal education is to be blamed. The accreditation boards for Architecture and Civil Engineering Programmes does not require skills on safety of the workforce therefore it affects the education curricula. Five local universities were analysed based on the subjects offered however none of them offer safety and health as a primary subject. This concept is new and yet to be adapted to the Malaysia's construction industry therefore an improved education for designers is highly needed and recommended. While commitment takes times, it is important to expand the knowledge and awareness to the accreditation boards, universities, colleges, societies and industries.

Key words: Malaysia, University Curricula, Safety Education, Safety Design, Designer

1.0 Introduction

Prevention through Design (PtD) is a concept addressing occupational safety and health during the design process by designing out potential hazards and risks associated with processes, structures, equipment that takes into consideration on the construction, manufacturer use, maintenance and decommissioning of a structure (Manuele, 2008). Applying Prevention through Design concept to the construction industry is called Design for Construction Safety (DfCS). DfCS is a viable method and one of a holistic approach in minimizing and reducing project risk while enhancing workers safety. In short, the definition can be described as designing for constructability. This means the design will be thoroughly reviewed to ensure that it can be safely constructed while fulfilling the cost, schedule and quality goals (Toole and Gambatese, 2008).

It is an ethical obligation for designers to address construction safety in their designs. The code of ethics provides adequate mandate for addressing safety in the design but this has not been a successful implementation in the construction industry culture (Hinze,2000). Even in OSHA stated that all parties need to control safety and health on the construction site (Reese andEidson, 2006). All parties refer to all individuals or companies that are involved in the project from the beginning to the completion of the project consist of Clients, Architects, Engineers, Contractors and Sub-Contractors.

The implementation of DfCS has not been successful enough to change the culture of the construction industry. Culture means having to act spontaneously without doubts or command from others. This culture has not been performed by the designers especially in the design phase. The developments of safety culture are based on the action taken by an individual that transform the act to the group. With all parties taking part in the organizational culture, the understanding of the importance of safety in the context of design may change the attitude and behaviour. Moreover, the organizational culture will be transmitted to all organization activities and in return be instilled to every member in the organization (MohdSaidin and Abdul Hakim, 2007).

There are plenty of barriers preventing the concept to be success and this should be overcome in the near future. One of the main barriers is the safety education of the designers involved in a project. The designers; architects and engineers are unable to consider safety in their design due to their lack of knowledge in construction method as well as construction safety.

According to Almen *et. al.* (2012), the architects admit that their knowledge in construction method is limited or not sufficient enough where they are unable to identify hazards related to the shape, framework and exterior of the building. They argued that the responsibilities to avoid hazards by taking appropriate measures such as personal protective equipment are solely on the construction managers and workers themselves.

Although the argument had a point, however, the physical condition on site is based on the design. Therefore, the designers have influence on the hazards and risks that exist on the construction site. Their decision towards the design may give high impact and affect the site condition especially in the safety context towards the workforce. The preventive measures to avoid hazards and risks that occur on site are the responsibility of the project managers in charge. However, it is also ethical and by law, that the designers should eliminate or reduce them during construction towards the workforce by taking safety into consideration in their design where it is possible and practicable. Sadly, the architects and engineers are not well-trained and educated in the safety of the construction workers therefore, it is impossible for this concept to succeed without an aggressive and immediate action towards their education.

2.0 The Need of Design Safety Education

The significant problem of design safety is the design professionals. Majority of them are unable to incorporate occupational health and safety considerations into their designs Cooke e*t. al*., 2008). A survey done in 2002 found that 20% from the 75 United States engineering firms indicated that more than half of their employees had received safety training. However, the other 70% reported that less than 25% employees of theirs had received safety training (Gambatese, 2003). This indicates that there is a need to improve the university and college education curricula on the construction safety culture so that the implementation of DfCS will be fully successful.

A wise comparison made by Morris in Gerber (2009)on the knowledge of health and medicine to knowledge of construction legal. He stated that the patient need to know enough information on health and medicine to practice preventive measures such as when to take the appropriate medicine prescribed and basic knowledge on the usage of aspirin and paracetamol. As to the construction professional, they need to know adequate information on legal matters such as their obligation towards the public and the requirements to the disabled. True to that, designers should also have sufficient knowledge on construction techniques, methods and safety to practice preventive measures so as to ensure the safety of the construction workforce. This statement is agreed by the Australian Safety and Compensation Council. The engineers need to learn the basic principles of Occupational Health and Safety while understanding how to apply to professional engineering design. The plan is not to teach the designers to be a safety engineer or a safety officer but to instil skills in order to be able to identify and respond to safety design that they are likely to encounter. It should be a skill based subject not a knowledge based subject.

This concept is fully supported by the contractors. They felt that the architects and engineers should receive health and safety education. According to Smallwood (1996), their comments on the concept are that the health and safety problem, solution or preventive measures rest with all of the parties involved. You are either the part of the solution team or the part of the problem. The designers should be fully aware of the safety requirements in compliance with the OSH Act, have a general view and understanding of how the design would be built by the contractor and take practical safety requirements into consideration when designing a structure or a building.

As designers, their role in decision making and designing, they need to understand how to manage risk and applying solution and control measures to their project design. They need to (ASCC, 2006):

i. have knowledge of workplace hazards and their harmful effects
ii. understand common law, statutory OHS requirements, responsibilities and penalties
iii. understand the risk management process, including risk analysis techniques and practices used to control the harmful effects of hazards
iv. understand the principles of designing to minimize human error
v. be aware of how design can impact on reliability, safety and unwanted capabilities
vi. be aware of sources information relating OSH.

The designers have not been trained to address construction safety in their design. This dilemma can be solved by educating the designers with the needed knowledge to enter the professional world so that their designs will be safer for the construction workforce (Hinze, 2000). It is at most important that the formal education step up to help minimize the barriers of implementing DfCS concept.

They may include design safety to the undergraduates curricular during their formal education. Mann III (2008) recommended that the educational curricula could be introduced through existing modules rather than in courses or seminars. With many support of past researchers on the improvement of education curricula to instil safety knowledge to the designer in universities and colleges' level, these practicing professionals feels the opposite. They feel that this step taken will become ineffective unless the industry changed its standards to incorporate the concept during practicing at firms (Behm, 2008). The reason for the disagreement is that the fresh graduates of architects and engineers' skills and requirements are based on the wants and needs of the employers wherein the current culture, the firms are not practicing this concept. Therefore, the skills equipped will become unwanted and not useful when entering the working environment. If the academic community take a lead role in supporting the designers to address safety in the design, a paradigm shift will never take place since the designers will be taught that the best and only way to approach a design is by taking into considerations the safety of the workforce (Hinze, 2000). Therefore, the safety design skills would be a necessity and an added advantage to the graduate designer in the design industry.

3.0 Accreditation Programme

Formal education in construction safety is important for construction field students. Though safety is a crucial topic in the construction culture, it has not significantly influenced the construction education in colleges and universities (Suckarieh and Diamantes, 1996). The university programs in construction management, engineering and architecture have limited discussion and focus on the topic of safety on construction project. With the implementation of design safety concept or Design for Construction Safety, it may not be fully successful without being addressed aggressively in universities with the full support of the accreditation bodies. Accreditation is an official acceptance and endorsement that a programme has been assessed and accredited to have attained the approved standard required. Each programme will be accredited by their professional board respectively.

3.1 Council of Architectural Education Malaysia (CAEM)

In Malaysia, the board of Architect is responsible for the accreditation of architect programme. It was formed under the provisions of the Architects Acts 1967 and empowered the Council of Architectural Education Malaysia (CAEM) to regulate all matters relating architectural studies. The main objective is to ensure that the standards attained by successful graduates of the programmes are adequate with regard to the design, technical and professional skills required.

3.2 Engineering Accreditation Council (EAC)

For the programmes in Civil Engineering, the Board of Engineers (BEM) has a duty to ensure that the quality of engineering education programme attains the minimum standard comparable to global practice by delegating Engineering Accreditation Council (EAC) for accreditation of engineering degrees. The objective of accreditation is to ensure that the graduate acquire the minimum academic requirements for registration as a graduate engineer with the Board of Engineers Malaysia (BEM) and for admission to graduate membership of IEM.

4.0 Designers' Universities Curricular

An article in the International E-Journal of Construction reported that very few civil engineering programs included construction safety in their curriculum (Gambatese, 2003). Perhaps the professors or head of faculties are not fully aware of the role that the designers have in the construction safety. Thus, the initial step in accomplishing this is through the accreditation requirements of the accreditation board (Hinze, 2000). Table 1 shows the skills requirement for the accreditation of Architecture and Civil Engineering Programme according to the Council of Architectural Education Malaysia (CAEM) and Engineering Accreditation Council (EAC).

Table 1 - Skills Requirement under the Accreditation Board (CAEM, 2013 and EAC, 2012)

No.	Architecture Programme	Civil Engineering Programme
1.	**LAM Part I - Design** Knowledge of analysis, research, budget, preparation and development of a brief design proposal, regulatory frameworks, health and safety consideration and architectural histories and theories	**Engineering Knowledge** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of complex engineering problems
2.	**LAM Part I -Technology and environment** The principles of building technologies, environmental design and construction method, the impact on design legislation, codes of practice and health and safety both during construction and occupation	**Problem Analysis** Identify, formulate, research and analyse complex engineering problems reaching conclusions using first principles of mathematics, natural sciences and engineering sciences
3.	**LAM Part I -Cultural Context** The awareness of the influences on the contemporary built environment, the knowledge of the histories and theories of architecture and ability to form judgments about the spatial, aesthetic, technical and social qualities of a design	**Design/Development of Solutions** Design solutions for complex engineering problems and design systems, components or processes with appropriate consideration for public health and safety, cultural, societal, and environmental
4.	**LAM Part I –Communication** Able to convey and critically appraise design ideas and proposals, use the conventions of architectural 2-D and 3-D graphics and listen and critically respond to the views of others	**Investigation** Conduct investigation into complex problems using research based knowledge and research methods including design of experiments, analysis and interpretation of data
5.	**LAM Part I - Management Practice and Law** Principles of business management, how buildings are designed and built and ability to manage their working practices, whether independently or collaboratively	**Modern Tool Usage** Create, select and apply appropriate techniques, resources, modern engineering and IT tools, to complex engineering activities, with an understanding of the limitations
6.	**LAM Part II – Design** Understanding of the regulatory requirements, including the needs of disabled, health and safety legislation and building regulations	**The Engineer and Society** Knowledge to assess societal, health, safety, legal and cultural issues and the responsibilities relevant to professional engineering practice
7.	**LAM Part II - Technology and environment** Ability to devise constructional strategies, structural theories, construction techniques and processes, characteristics of building materials and the environmental impact of specification choices	**Environment and Sustainability** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development
8.	**LAM Part II - Cultural Context** Ability to judge about the spatial, aesthetic, technical and social qualities of a design and critically appraise their ideas	**Ethics** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice
8.	**LAM Part II - Communication** Ability to critically appraise the most appropriate techniques available, produce documentation and reports covering a range of architectural issues of culture, theory and design.	**Communication** Communicate effectively on complex engineering activities, being able to write effective reports and design documentation and give and receive clear instructions
9.	**LAM Part II - Management Practice and Law** Understanding the inter-relationships of individuals and organisations, the fundamental legal, statutory requirements, duties and responsibilities of architects	**Individual and Team Work** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings
10.		**Life Long Learning** Ability to engage in independent and life-long learning in the broadest context of technological change
11.		**Project Management and Finance** Understanding of engineering and management principles, manage projects in multidisciplinary environments

Based on Table 1, there are five main required skills for LAM Part I and LAM Part II, which consist of Design, Technology and Environment, Cultural Context, Communication and Management Practice and Law. In regards to safety and health, the graduate architects are required to have sound knowledge on health and safety consideration and legislation as well as understanding occupational health and safety during and after construction of a project. However, for the Civil Engineers, there are 11 skills requirements which include the knowledge on engineering, analysis and investigations, design, communication, ethics as well as project management. In terms of safety and health, graduates of civil engineers are required to be able to provide design solution in consideration to public health and safety as well as knowledge on health and safety legislation.

The accreditation board of architect requires the programme to instil understanding of health and safety during construction but not specifically to their design. As opposite to the civil engineer programme, the board insist that the students are able to provide design solution in regards to health and safety of the public but not towards the health and safety of the construction workers. None of the both accreditation boards require skills on health and safety of the workforce to be taken into consideration during the design phase. Therefore, this explains why no specific course for health and safety is provided by the universities in Malaysia for both programmes as shown in Table 2 and Table 3.

Table 2–Courses offer by Civil Engineering Programme

No.	University	Accreditation By EAC	Subjects / Courses			
			Const. Materials	Const. Management	Const. Technology	Safety and Health
1.	UniversitiTeknologi Malaysia (UTM)	✓	o	✓	✓	o
2.	UniversitiTeknologi Mara (UiTM)	✓	✓	✓	✓	o
3.	Universiti Putra Malaysia (UPM)	✓	✓	✓	✓	o
4.	Infrastructure University KL (IUKL)	✓	✓	✓	✓	o
5.	SEGI University	o	✓	✓	✓	o

Table 3–Courses offers by Architecture Programme

No.	University	Accreditation by CAEM	Subjects / Courses			
			Building. Materials	Building Management	Building Technology	Safety and Health
1.	UniversitiTeknologi Malaysia (UTM)	✓	o	✓	✓	O
2.	Infrastructure University KL (IUKL)	✓	o	✓	✓	O
3.	International Islamic University Malaysia (IIUM)	✓	o	✓	✓	O
4.	Taylor's University	✓	✓	✓	✓	O
5.	University Malaya (UM)	✓	✓	✓	O	O

Five local universities were analysed based on the subjects offered for Civil Engineering Programme and Architecture Programme. As shown in Table 2, 4 out of 5 universities for Civil Engineering Programme are accredited by the EAC. All of the universities offer Construction Management and Construction Technology subject to students while 4 out of 5 universities offer Construction Materials subject. With these three subjects, it shows that the universities are equipping future engineers with deep knowledge on the construction method, process and management. However, none of the universities offer safety and health as a primary subject to be taken in order to graduate. For the Architecture programme, shown in Table 3, five accredited universities were analysed whereas 3 of the universities does not offer Building Materials subject in their programme thus producing graduates with poor knowledge on the usage of hazardous materials and the availability of subsequent materials.

While the majority of the universities provide subjects on the technology and management, as predicted, none of them offer safety and health subject. The requirement skills under the accreditation board do not include the health and safety subject therefore; both the architecture and engineering did not make an effort to include it as a primary course in the universities. Most university construction programs are structures with courses that are technical in nature and necessary to educate the students in their respective profession. Therefore, practicing professional often improve their knowledge on construction safety by continuing education courses (Suckarieh and Diamantes, 1996).

Mann III (2008) suggested that the health and safety topic is to be incorporated into existing courses such as timber design, steel design and concrete design subjects. He added that the undergraduates as well as the faculties may accomplished largely through teaching modules and case studies added to the existing curricula, rather than through entire new courses. In the University of Cincinnati, the students are required to review and observe an operational construction site and write a report on the techniques used and suggest improvements and innovative techniques to improve the safety measures on the site in the context of the safety of the workforce involved (Suckarieh and Diamantes, 1996). The basic approach would be to address relevant construction techniques and methods in every design and to show how specific design decisions can influence the safety of the construction worker.

5.0 Recommendation

In order to perform or implement design safety concept in this industry successfully, an improved education for designers is highly needed and recommended. It can be incorporated into the curricular while increasing the educators', professors' and faculties members' awareness towards the concept (ASCC, 2006). They must recognise the importance of safety education in the context of the construction worker to the construction site environment. Then only they are able to instil the design safety skills to the undergraduate with success.The educational tools and modules should include both theoretical and industrial experience knowledge in order for the students to be able to adapt the theory in their design based on real life construction environment.

This effort should continue by educating practicing professionals by continuing education, workshop or seminars provided by the boards. It will be more efficient if it is made as a requirement to attend the seminars in order to renew or register their professional license annually. This is in order to increase the awareness of the professional on this matter. Moreover, it may change their mind-set and the culture of the construction industry and allows them to apply the concept successfully where practicable.

6.0 Conclusion

This concept is new and yet to be implemented to the Malaysia's construction industry. The initial step to be taken in order for our culture to adapt this concept is the improvement of designer's curricula in the universities and colleges level. Safety design can be initially adapted to the existing course and gradually improve as a primary subject to the undergraduate designers so as to increase the level of awareness and knowledge on this matter. While commitment takes times, it is important to expand the knowledge and concept to faculty members, while establishing liaisons with universities, colleges, societies, industries and labours to increase awareness. This concept not only provides a safe construction environment to the workforce but to the health and safety of the public as well.

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