

Prevention through Design (PtD) in AEC Programs: Educators' Perspective

Somik Ghosh, PhD
University of Oklahoma
Norman, Oklahoma
Sandeep Langar, PhD
University of Southern Mississippi
Hattiesburg, Mississippi
Mohammed S. Hashem M. Mehany, PhD, PMP
Colorado State University
Fort Collins, Colorado
Suchismita Bhattacharjee, PhD
University of Oklahoma
Norman, Oklahoma

The US construction industry has historically accounted for high numbers of occupational fatalities and injuries in comparison to other industry sectors. These large number of accidents taking place in the project sites can be attributed to decisions made during the design phase of the project. Recognizing the effect of the decisions adopted during the design phase on the safety of the construction workers falls under the broader concept of Prevention through Design (PtD). The concept of PtD requires the participation of designers/engineers in addressing safety and health hazards of the construction workers during the design phase. This raises the natural question whether the designers/engineers are adequately trained to take up the additional responsibilities. Review of the accrediting agencies' requirements governing the Architecture/Engineering/Construction (AEC) programs revealed that the design programs are required to focus only on user safety, and construction programs are left to teach workers safety to their graduates. This paper presents the results of a survey to identify the educators' knowledge about PtD and the extent of PtD incorporation in their programs. Consistent with the requirements of the accrediting agencies of the different disciplines, the responses varied among the different groups. While the construction educators are more aware of the PtD concepts and few of them are currently incorporating PtD in their curricula, the respondents identified an overall lack of training for them to teach PtD to their students. The outcome of the survey can be used by the AEC programs to expand their curricula to incorporate PtD concepts.

Keywords: Prevention through Design, design, construction, AEC industry, educator

Introduction

The construction industry in the US is one of the most dangerous industries, regarding occupational safety. The numbers of injuries and illnesses in the US construction industry are disproportionately high in comparison to other industries. The construction industry approximately employed 7% of the total US workforce in 2011and accounted for more than 9% of all occupational fatalities. The same trend is observed in the years to follow as well. In 2014, there were 874 deaths in the construction industry, which was highest among all other industries (BLS 2014). The number of injuries is also excessively high in the construction industry compared to other industries. The significant number of fatalities and injuries can be attributed to various factors present in the construction sites as well as decisions and actions taken away from the construction sites. The effect of decisions taken further away from the project sites, even before construction activities begin, on the project performances including safety is a known fact. Multiple studies across the world have linked the decisions taken during the design phase to accidents occurring down the line during the construction phase (European Foundation 1991, NSW Workcover 2001, Behm 2005).

Recognizing the importance of decisions taken during the design phase in preventing accidents among downstream construction workers, and involving the designers/engineers in construction safety falls under the broader concept of Prevention through Design (PtD). A formal definition of PtD from American Society of Safety Engineers (ASSE) describes PtD as "*addressing occupational safety and health needs in the design process to prevent or minimize hazards and risks*" of workers down the line. This concept of identifying and eliminating hazards for construction workers during the design is not new. Szymberski (1997) claimed that the ideal time to consider construction safety is during conceptual and preliminary design phases to be more effective. The earliest reference to this concept can be found in the Accident Prevention Manual published in 1955 by the National Safety Council (NSC 1955). Later in 1985, the International Labor Office (ILO) also recognized that the architects and engineers could play a significant role in the safety of construction projects (ILO 1985).

As per Szymberski (1997), a typical construction project lifecycle comprises of five phases: conception, design, construction, operation/maintenance, and demolition/reuse. The designers/engineers are involved in the conception and the design phases and the impact of their decisions on enhancing the project safety is greater during these early phases of the project lifecycle. Hierarchy of controls in regards to safety considerations can be categorized into five levels: (1) elimination, (2) substitution, (3) engineering controls, (4) administrative controls, and (5) personal protective equipment, with 'elimination' being the most effective control measure. Among these various control measures, the higher level ones such as elimination or substitution are not dependent on the decisions of the field personnel, but largely on the decisions taken during the design phase. In this situation, the designers/engineers are best positioned to implement the higher level controls. However, the traditional perception of construction safety, that, it is the sole responsibility of the contractors is counterintuitive to the concept of PtD. In addition, the traditional delivery method of design-bid-build reinforces this view by separating the design and the construction phases with minimal interactions between the designers/engineers and the contractors. In contrast, the alternative delivery methods such as design-build, construction management at risk, and integrated project delivery, which are gaining popularity due to improved project performances that promote the overlaps of the design and construction phases and emphasize the collaboration of the designers/engineers and the contractors. As a natural corollary, these delivery methods are more conducive to the concept of PtD in comparison to the traditional design-bid-build. The alternative delivery methods also support the owners' concerns about workers' safety, which is perceived as critical to the increasingly demanding owners. Moreover, with owners being increasingly held responsible for worksite accidents by litigations (Hinze 2006; Huang and Hinze 2006), their interest in improving workers' safety is justifiable. Adoption of PtD will provide the opportunity to the owners to identify and reduce hazards that may cause accidents to the workers during planning and design phases by selecting designers/engineers who have the knowledge and are actively involved in safety. The owners are responsible for paying extra compensation to the designers/engineers if the owners require them to address construction safety during the design phase (Gambatese 2000a). While involving the designers/engineers, and contractors in addressing the workers' safety sound to be a logical plan, the pivotal question that arises: *Are all the entities adequately trained to take up the responsibilities?* Although contractors are traditionally encumbered with the worksite safety and are trained and educated in workers' safety and worksite safety management, a survey study conducted by Gambatese (2000b) identified lack of training and education of the designers/engineers to address workers' safety. With this disparity in the expectations and the capabilities, the authors turned towards the programs bestowing higher education and training to the future generations of designers/engineers, and contractors to gauge their perceptions. This paper presents the perceptions of the educators of the Architecture/Engineering/Construction (AEC) programs towards the concept of PtD. The paper presents a brief overview of the safety education for design, engineering, and construction students offered in the higher education programs followed by the details of the survey method adopted to collect perceptions of the educators about PtD and analysis of the survey responses.

Safety Education for Design, Construction, and Engineering Students

The Architecture and Interior Design education systems in the US are governed by accreditation organizations that set strict guidelines and expectations for the knowledge levels of the graduates coming out of the accredited programs. The National Architectural Accrediting Board (NAAB) is the sole agency in the US, which accredits professional degree programs in Architecture. The NAAB accreditation states programs are "*to produce graduates who: ... are able to solve architectural design problems, including the integration of technical systems and health and safety requirements; and comprehend architects' roles and responsibilities in society*" (NAAB 2014). Thus, the current NAAB standards require the students to be knowledgeable about user safety but reveal no specific requirement relating to the occupational safety of construction workers. The National Council of Architectural Registration Boards (NCARB) represents the architectural licensing boards. The council governs the process that provides the standardized architectural registration examination recognized by the licensing boards in the US. This organization, which has a critical role in architectural education, as the Council develops and recommends standards for architectural practice emphasizes public safety. In their mission statement, NCARB vows to protect "*the public health, safety, and welfare by leading the regulation of the practice of architecture through the development and application of standards for licensure and credentialing of architects*." (NCARB 2016).

Similar to the NAAB, Interior Design education in the US is governed by the Council for Interior Design Accreditation (CIDA). The CIDA is the only agency in the US accrediting Interior Design programs and currently has more than 150 accredited programs serving approximately 20,000 students. The CIDA has developed a professional standard used to evaluate Interior Design programs that prepare entry-level designers. As per the current professional standard of the CIDA, entry-level interior designers are expected to *"... use the principles of lighting, acoustics, thermal comfort, and indoor air quality to enhance the health, safety, welfare, and performance of building occupants."* The current CIDA standards resonate with the requirements of NAAB to focus on user safety and not require any occupational safety education for the interior designers. The National Council for Interior Design Qualification (NCIDQ), comprised of the US and Canadian regulatory boards states that "*A qualified interior designer is a key asset to any building construction team, lending knowledge and taking responsibility for critical features that protect public health, safety, and welfare*." (NCIDQ 2016).

The American Council for Construction Education (ACCE) is the accrediting agency for the construction programs offered in the US universities and colleges. It is expected that construction workers' safety will be considered with utmost importance in the requirements of the ACCE standards; the ability of the graduating students to "*create a construction project safety plan*" is listed as one of the highest cognition levels on the list of 20 student learning outcomes prescribed by the ACCE. Standalone course on occupational safety is common in most of the ACCE accredited construction programs, while some have embedded components of occupational safety and health in more than one course. A handful of programs have aligned their course(s) with NIOSH's PtD initiatives (Popov et al. 2013). NIOSH recommends certain success factors associated with embedding components of PtD in the curricula such as finding receptive individuals, being sensitive to competing curriculum demands, focusing on key aspects, using real cases, introducing problem-solving methods, and similar.

The Accreditation Board for Engineering and Technology (ABET) is responsible for providing accreditation to college and university programs in the disciplines of applied science, computing, engineering, and engineering technology. It also accredits a variety of programs both within and outside the US. Safety and related programs accredited by ABET such as Environmental Health and Safety, Industrial Hygiene, others have specific components of occupational safety and health in their curricula.

There is no denying that effective safety programs substantially reduce the accident rates by creating safer means of operation and work environments. Not only does effective safety education help in creating a safer environment, but

practitioners also agree it minimizes damage to equipment and tools, loss of market competition, and project delays. It is evident from the review that the accrediting agencies governing the Architectural and Interior Design programs do not necessitate the programs to include workers' safety in their curricula, but emphasize on user safety.

Objectives of the Study

The designers/engineers in addition to the contractors play a vital role in creating a safe job-site as they are responsible for determining the configurations, constructability, and the final design solutions of any built facility. For the designers/engineers to correctly implement measures to promote the safe job-site environment, it is important for them to have a sound knowledge about PtD. Thus, it is necessary to educate the current students of the design, engineering, and construction programs about PtD as they will be the future leaders of the AEC industry. The study attempts to understand the current level of awareness about PtD among the design, engineering, and construction educators as they are responsible for educating the future leaders of the AEC industry. The following objectives were identified to achieve the aforementioned goal of the study.

- Explore the familiarity and knowledge of PtD among the AEC educators.
- Explore and analyze the AEC educators' implementation of PtD within their respective programs.

Research Method

The objectives mentioned above were achieved by conducting a survey of the educators of design, engineering, and construction programs across the US. The survey questionnaire was divided into three sub-sections including: (1) understanding the demographics of the educators and their institutions; (2) understanding the background information of the educators as it relates to his/her level of education and area of expertise; and (3) examining the educators' level of awareness about PtD and the institutions' level of implementation of PtD as part of core educational curricula. The overall research process of the study involved the following steps: (1) selecting sample educators of design, engineering and construction programs; (2) developing the survey instruments; (3) conducting pre-test for instrument validation; (4) distributing the survey questionnaire to selected samples; (5) collecting data to examine the level of knowledge and implementation of PtD among design, engineering and construction educators; and (6) analyzing the collected data.

Scope of the Study and Sample Selection

Survey questionnaires were distributed to the educators of design, engineering and construction programs in the US. The population comprised of the educators from the member institutions of Associated Schools of Construction (ASC), American Society of Engineering Education (ASEE) and Association of Collegiate Schools of Architecture (ACSA) and Interior Design Educators Council (IDEC). The targeted population provided diversity regarding program sizes, geographic locations, and more importantly, represented the entire AEC educational disciplines' educators.

Survey Design

The survey questionnaires were composed of two types of questions: (1) questions with ordered choices, and (2) questions with Likert-type scale. The questionnaire was divided into three sections. The first section consisted of questions on demographics which were related to identification and differentiation of participants such as educator's title, institution's location, educator's discipline, department/program's background and size. The second section

further enquired about the respondents' educational background and areas of expertise. The third section examined the respondents' level of knowledge about PtD, and level of implementation of PtD in classroom education.

The authors identified the survey items based on the study's key constructs of interest. Once the first draft of the survey instrument was developed, research measurement experts reviewed those to ascertain the content validity of the items regarding relevance, representativeness, and technical quality. The authors have sought consultation from professionals experienced in research methodology, measurement, and applied statistics used in conducting social science research. These individuals, trained in measurement helped with the construct validity of the instrument. Feedbacks from the research measurement experts was incorporated into the second draft, the pretest version of the survey instruments. Five AEC educators reviewed the pretest version of the survey for relevance and representativeness. Feedbacks obtained on the pretest version were incorporated into the final version of the survey instrument. A few typographical errors were corrected and several words in the questions were revised to increase clarity.

Distribution of Survey Questionnaires and Collection of Data

The developed and validated survey instrument was encoded using a web survey tool to facilitate the distribution and collection of the survey questionnaires via the internet. After successfully developing the web survey questionnaire, the invitation email along with the survey questionnaire was emailed to the study sample.

Results

The survey was distributed to educators in ASC, ASEE, ACSA, and IDEC. At the completion of the survey, approximately 67 programs across the US and Canada had participated. After eliminating incomplete responses, data from 58 educational programs was analyzed. Approximately 43.1% and 41.4% of the respondents identified themselves with Interior Design/ Interior Architecture and Construction Programs respectively (Table 1). The majority of the respondents were at the rank of Assistant Professor (32.8%) followed by Associate Professor (29.3%). Geographically, the locations of the institutions were mapped onto the US Census Map. The US Census Map divides the US into four major parts: Northeast, South, Midwest, and West. The majority of the responding programs to the survey were geographically located in the Southern US (41.4%) followed the Midwest and the Western US, each at 20.7%. Only 8.6% of the responding educational institutes were geographically located in the North Eastern US. Additionally, all three responding international educational institutes were geographically located in Canada.

Table 1

Firm Demographics of Survey Respondents

Item	Group	Number	Percentage
Discipline that best described Department/Program	Architecture + Construction	3	5.2%
	Construction	24	41.4%
	Engineering	4	6.9%
	Interior Design/ Interior Architecture	25	43.1%
	Project Management	1	1.7%
	Other	1	1.7%
	Total Participating programs	58	
Respondent Titles	Adjunct instructor	2	3.4%
	Lecturer	1	1.7%
	Senior Instructor	1	1.7%
	Assistant Professor	19	32.8%
	Associate Professor	17	29.3%
	Director and Professor	2	3.4%
	Program Director	1	1.7%
	Professor	12	20.7%
	Other	3	5.2%
	Total Participating programs	58	
Respondent Geographical location	International	3	5.2%
	Midwest	12	20.7%
	North East	5	8.6%
	Not Identified	2	3.4%
	South	24	41.4%
	West	12	20.7%

Adoption and implementation trends for safety and PtD courses in programs

As discussed in the literature, there is a greater push for ensuring on-site safety and PtD can be one of the main practices to improve construction safety. Since the goal of the study was to ascertain PtD adoption and implementation among educational programs, the prerequisite was to identify if educational programs taught any "safety" related course(s) in the Program. Even though “safety” is a component of Student Learning Outcomes (SLO) under the new ACCE (American Council for Construction Education) accreditation, the authors wanted to ascertain the implementation of the concept. Also, the authors want to emphasize that the responding institutes are spread across the different AEC disciplines that include various accreditation bodies other than the ACCE. Approximately 41.4% of the respondents were familiar with the concept of PtD, and 48.3% of the respondents identified that they teach a course related to safety. The respondents also reported that 43.1% of the educational programs offered a standalone course in safety with the majority (76.0%) of the adopters identified as construction programs. Only 8% (tie) of the programs which offers a standalone course in safety were affiliated with the Engineering or Architecture Programs. Thereby, emphasizing the need for offering courses that introduce the concept of PtD to the students. The relevance of PtD is enhanced when designers/engineers are aware of the concept, which is not the current case at the curriculum level in such programs. In addition, only 28% of the respondents among the programs that offered standalone safety courses reported that they introduce PtD as part of

the safety education. Therefore, indicating that the PtD concept among the AEC education curriculum needs to be emphasized. Furthermore, the majority of the educators (80%) have rated PtD training as "important to extremely important" within programs that offer standalone safety courses which are proof that they realize the importance of PtD training. Despite the positive perceptions of respondents towards PtD training, only 20% of respondents had attended any PtD training/workshops/seminars while a majority (76%) of the respondents had not attended any form of PtD training.

Table 2

Adoption and implementation trends for safety and PtD courses in programs

Item	Group	Number	Percentage
Familiar about PtD (Prevention through Design) concept and implement	No	34	58.6%
	Yes	24	41.4%
Offer standalone safety courses in your Department/Program?	**No**	**12**	**20.7%**
	Architecture + Construction Program	1	8.3%
	Construction Program	5	41.7%
	Engineering	2	16.7%
	Interior Design	4	33.3%
	Yes	**25**	**43.1%**
	Architecture + Construction Program	2	8.0%
	Construction Program	19	76.0%
	Engineering	2	8.0%
	Interior Design	0	0.0%
	Other	1	4.0%
	Project Management	1	4.0%
	No response	**21**	**36.2%**
	Interior Design	21	100.0%
PtD teaching among programs that offer standalone safety courses	No	17	68.0%
	Yes	7	28.0%
	No Response	1	4.0%
Safety education integrated with the program curriculum, among programs that offer standalone safety courses	No	4	16.0%
	Yes	21	84.0%
	No Response	0	0.0%
No. of courses in which safety education is integrated with the program curriculum, among programs that offer standalone safety courses	None	6	24.0%
	One Course	2	8.0%
	2-4 Courses	12	48.0%
	5-8 Courses	4	16.0%
	More than 8 Courses	0	0.0%
	All	1	4.0%
PtD introduced as part of the safety education, among programs that offer standalone safety courses	No	14	56.0%
	Yes	6	24.0%
	No Response	5	20.0%
	No response	17	68.0%

No. of courses in which PtD is addressed, among programs that offer standalone safety courses	1 Course	6	24.0%
	2-4 Courses	2	8.0%
	More than 5 Courses	0	0.0%
Existence of the PtD champion, among programs that offer standalone safety courses	No	19	76.0%
	Yes	5	20.0%
	No Response	1	4.0%
Existence of the PtD champion, where PtD is introduced as part of the safety education	No	3	50.0%
	Yes	3	50.0%
	No Response	0	0.0%
Attendance to any PtD training/workshops/seminars, for educators within programs that offer standalone safety courses	No	19	76.0%
	Yes	5	20.0%
	No Response	1	4.0%
Attendance to any PtD training/workshops/seminars, where PtD is introduced as part of the safety education	No	4	66.7%
	Yes	2	33.3%
	No Response	0	0.0%

Conclusion and Future Research

The aim of this research study was to ascertain the implementation of safety and PtD in among the AEC educational programs to support the rapidly evolving AEC industry. The study found that the majority of design (Architecture and Interior design) and engineering programs had little or no focus towards occupational safety or PtD within their programs. Also, programs such as construction, or engineering, historically that have been champions for safety have been lagging in the concept of PtD or the holistic association of safety with the education curricula. The study has also identified the lack of knowledge, implementation, and training among AEC educators on the latest practices in safety such as PtD. Ultimately this impacts the integration of safety practices within the AEC programs, specifically in design and engineering programs. This gap should be addressed to have quality educators who can develop updated curriculums and produce informed/knowledgeable graduates who are familiar with the safety concepts including PtD. Hence, improve the job-site safety. On a positive note, most of the educators emphasize the need for training and the willingness to improve the safety education paradigm, which in turn is an excellent motive to progress and enhance the knowledge of safety (including PtD) in AEC educational curriculum. The study also found that the majority of programs lacked PtD champions who could propagate the concept. The absence of PtD champions within the programs can be a primary reason for the lack of safety and PtD adoption in the AEC educational curriculum.

The current paper addresses an imminent gap at the interface of the future construction safety practice and the AEC education programs. PtD is a proactive approach to reduce occupational hazards of construction workers by managing decisions at the design phases. Current design curricula discount workers safety as responsibilities of designers. Therefore, to raise the future designers'/engineers' awareness about construction safety, efforts should be invested to develop different approaches in which PtD concepts can be incorporated into the AEC curricula so that students can gain knowledge of PtD before taking up professional responsibilities in their respective disciplines. More training for educators is needed to achieve this goal.

References

Behm, M. (2005). Linking construction fatalities to the design for construction safety concept. Safety Science, 43(8), 589-611.

BLS (Bureau of Labor Statistics). (2014). "Census of fatal occupational injuries (CFOI)—Current and revised data." <http://www.bls.gov/iif>.

European Foundation. (1991). "From drawing board to building site:Working conditions, quality, economic performance." EF/88/17/FR, European Foundation for the Improvement of Living and Working Conditions, Dublin, Ireland.

Gambatese, J. A. (2000a). "Owner involvement in construction site safety." Proc., Construction Congress VI: Building Together for a Better Tomorrow in an Increasingly Complex World, ASCE, Reston, VA.

Gambatese, J. A. (2000b). "Designer involvement in construction site safety." Proc., Construction Congress VI: Building Together for a Better Tomorrow in an Increasingly Complex World, ASCE, Reston, VA.

Hinze, J. (2006). Construction safety, 2nd Ed., Pearson Education, Prentice Hall, Upper Saddle River, NJ.

Huang, X., and Hinze, J. (2006). "Owner's role in construction safety." Journal of Construction Engineering and Management, 132:2(164), 164–173.

ILO (1985). "Safety and Health in Building and Civil Engineering Work". International labor Office (ILO), Geneva.

NSW Workcover. (2001). "CHAIR—Safety design tool." Gosford, NSW, Australia.

Popov, G., Blunt, L. A., McGlothlin, J., Young-Corbett, D., Zey, J. N., & Heckel, P. (2013). "Education: Integrating PTD into undergraduate curricula." Professional safety, *58*(3), 44.

Szymberski, R. (1997). Construction Project Safety Planning. TAPPI Journal, 80(11), 69-74.