Original Article

Capturing Prevention through Design Practices through the Lens of Industry Practitioners' Experiences in Occupational Safety and Health in Construction Industry Management Projects

Che Khairil Izam Che Ibrahim,[a,*] Sheila Belayutham,[a] Mazlina Zaira Mohammad,[a] Shafienaz Ismail[a]

[a] *Faculty of Civil Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia*

[*]Corresponding author: chekhairil449@uitm.edu.my

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ABSTRACT: *Prevention through Design (PtD) is an innovative concept that aims to transform the currently fragmented health and safety practices into a consolidated approach by designing out hazards and risks in the early design phases of a construction project. As PtD has gained attention in the Malaysian construction industry through the recent introduction of the Occupational Safety and Health in Construction Industry (Management) (OSHCIM) guideline in 2017, having in-depth knowledge of PtD practices to fulfill OSHCIM requirements in construction is imperative. This study explores the knowledge and skills involved in practicing PtD through the lenses of practitioners with experience in the pilot OSHCIM projects. Data were collected qualitatively through two series of online focus group sessions conducted with experienced OSHCIM practitioners. The findings indicate that PtD practices could be a game changer for designers, especially in safety and health practices. However, PtD-related tacit and explicit knowledge, as well as PtD-related technical and collaborative skills among designers, need to be enhanced to fulfill designers' duties, as stipulated in the OSHCIM. The findings also indicate that such pilot OSHCIM projects could act as a practical platform of best practices and lessons learned, which can be shared with the wider construction community to close the 'knowledge gap' regarding PtD practices. Subsequently, this study provides insight into the necessary knowledge and skills required for PtD diffusion, mitigating possible concerns among designers regarding OSHCIM implementation, where a new normal of practice is required when OSHCIM is mandated in the future.*

Keywords: *Construction, Prevention through Design (PtD), Safe Design.*

1. INTRODUCTION

Accidents and fatalities are well-recognized in construction worldwide. Similar to other developing countries, Malaysia's construction industry is one of the most dangerous industries, with the highest death rate compared to other industries. In 2019, the Malaysian construction sector recorded 84 fatalities, 15 permanent disabilities, and 227 non-permanent disabilities (Department of Occupational Safety and Health (DOSH), 2020). The rising accident rate in the Malaysian construction industry has led the Ministry of Human Resources, through the DOSH, to introduce a new initiative: integrating the prevention through design (PtD) concept into the existing occupational safety and health (OSH) and risk management. The guidelines on Occupational Safety and Health in the Construction Industry (OSHCIM) were launched in 2017, and they emphasize the need to anticipate and 'design out' risks and hazards (in tools, equipment, processes, materials, and structures) at the early design stages in construction projects.

It is worth highlighting that the OSHCIM was developed based on Construction Design and Management (CDM) in the United Kingdom, and this concept has been widely accepted in other countries under specific legislative frameworks. For instance, PtD has been mandated under the CDM regulations 2015 in the UK, the Model Work Health and Safety Act 2011 in Australia, the Health and Safety at Work Act 2015 in New Zealand, and the Workplace Safety and Health Regulations 2015 in Singapore. By contrast, countries such as the United States and Hong Kong have voluntarily been driving this concept.

Considering that the influence of PtD-related legislation in reducing accident occurrence is significant (Toole and Gambatese, 2008; Gambatese et al., 2017), and considering the influence of OSHCIM in OSH management, an investigation into PtD practices in Malaysia is timely and significant. Efforts to understand the current state of OSHCIM practice cannot be overlooked, as they could assist in providing practical insights that could facilitate the progress of OSHCIM practice among construction organizations. As part of a wider study to understand PtD competencies, this study aims to explore the knowledge and skills involved in practicing PtD through the lens of practitioners with experience in pilot OSHCIM projects. The role of a designer or organization (those who have design responsibilities) in PtD practice is crucial, as they are expected to produce inherently safer designs for the lifecycle of a project and, at the same time, fulfill their ethical duty to the safety and health of human beings (Manu et al., 2019).

2. THE RECENT PTD STUDIES IN THE CONSTRUCTION DOMAIN

A growing number of studies have been conducted in recent years on PtD-related issues during construction. However, the intention here is not to review the broader PtD literature but to concentrate on recent PtD-related research (over the past three years) in construction. The Scopus database was selected as an appropriate search platform because it has the largest database, is comprehensive, and has wider coverage (Yi and Yang, 2014). Scopus has also been used in many construction studies focusing on various areas (e.g., OSH, digital, collaboration, and project management) (Che Ibrahim et al., 2020).

The search was performed in December 2019 and covered articles published from 2018 to 2020. The complete keywords used for this search were "prevention through design," "safety by design," "construction design management," "design for safety," "safety in design," "design risk management," and "construction." The initial search returned 61 papers which was reduced to 41 papers (due to duplications and conference proceedings) screening. To discover the patterns of recent studies, we split the timeframe of the selected articles into three sub-periods (See Table 1) and summarized each study based on year of publication.

Table 1. Snapshots of Recent PtD-Related Studies in Construction Domain

Key features / Year	2018	2019	2020
No. of relevant articles	8	16	17
Main Topic	Application in infrastructure projects, Integration of BIM, Implementation factors	Organizational Capability, BIM, Serious gaming	Digital Tool, Education, Organizational Capability, BIM, KAP, Hazard recognition, Communication
Context of Study	Review, Process, Perception, Project	Review, Simulation, Perception, Conceptual	Review, Automation, Competency, Perception
Terminology	DfS, PtD	PtD, CDM	CDM, PtD, DfS, DfOSH
Methodological Framework	Desk Study, Case study, Survey, Interview	Desk Study, Case Study, Survey, Interview	Desk Study, Case study, Survey, Interview, Observation
Geographical Setting	Ghana, Singapore, China, US, Korea, Italy	UK, US, Nigeria,	UK, US, Malaysia, Palestine, Australia, China

KAP, Knowledge, attitude, and practices; BIM, Building Information Modeling

In 2018, PtD-related literature on construction emerged within the context of establishing a clear application in certain types of projects, such as tunnels and subways. Building Information Modeling (BIM) also gained attention from scholars during this period. Qualitative and quantitative methodological frameworks were used during this period. Studies in this period mainly focused on developed countries, such as the US, China, Korea, Italy, and the UK. In 2019, studies on PtD focused primarily on organizational capability and education. Interest in PtD and BIM activities continued to increase during this period. While studies focused mainly on the UK and the US, PtD studies started to grow to developing countries such as Nigeria. In the year 2020, research expanded to include more focused multidimensional PtD topics such as hazard recognition, communication, and the development of PtD tools. Further, studies adopted more qualitative methodologies. This period also saw an increase in studies conducted in developing countries, such as Malaysia and Palestine.

Overall, despite the continued growth in the PtD literature, studies in developing countries are still limited. In particular, in Malaysia, where PtD practice is still in its infancy owing to the quite recent implementation of OSHCIM, more studies need to be conducted to expand PtD knowledge in the context of construction.

3.0 METHOD

This study adopted a pragmatic methodological approach using a qualitative methodology, particularly online focus group (FG) discussions. Given the coronavirus disease 2019 (COVID-19) pandemic and the enforcement of the Enhanced Movement Control Order during the study, conducting discussions online approach was the best option. Two online FG sessions were conducted (See Table 2) to discuss key PtD competency attributes.

As this study necessitated the need for information-rich participants (i.e., practitioners with experience in PtD-related practice), a purposive sampling strategy was used to select the participants. Thus, participants were selected through recommendations from the DOSH. In particular, those who were involved in OSHCIM pilot projects were invited. As PtD is a relatively new practice in Malaysia, including participants with experience in OSHCIM activities is crucial for enabling more conclusive and genuine feedback on designers' capabilities to engage in PtD practices.

Table 2. PtD Focus Group Session

Meeting	Date	Type of Organization	No. of Participant	Designation	Online Platform
FG Discussion	April 2020	Regulatory Body Technical agency Developer Consultant/Contractor	18	Civil & Structural Mechanical & Electrical Quantity Surveyor Architect Safety & Health Officer	Google Meets
FG Discussion	May 2020	Regulatory Body Developer Consultant Contractor	8	Civil & Structural Mechanical & Electrical Quantity Surveyor Architect Safety & Health Officer	Microsoft Teams

A total of 26 industry professionals (73.1% (19 male) and 26.9% (7 female)) with an average of 15 years of experience in the construction industry participated in the two FG sessions. The participants included nine architects (34.6%), seven safety and health architects (26.9%), four civil, structural, mechanical, and electrical architects (15.4%), and two quantity surveyors (7.7%). The majority of respondents were registered professionals from various professional bodies. The respondents' demographic details are shown in Table 3.

Four researchers facilitated the FG sessions. The FG interviews lasted for an average of two hours. The sessions were conducted mainly in English to ensure that accurate contextual meaning was captured during data collection and to avoid problems with interpretation during the analysis. In addition, all discussions were digitally recorded (with permission from the participants) using the features provided in the videoconferencing applications (i.e., Google Meets and Microsoft Teams).

Table 3. Summary of Respondents' Demographics

Demographic Profile	Respondent characteristics	No. of respondents (N = 26)	%
Disciplines	Civil & Structural	4	15.4
	Architect	9	34.6
	Mechanical & Electrical	4	15.4
	Quantity Surveyor	2	7.7
	Safety & Health	7	26.9
Organization	Government Agencies	10	38.5
	Developer/Owner	9	34.6
	Consultant	4	15.4
	Contractor	3	11.5
Academic Qualification	Degree	11	42.3
	Master	13	50.0
	PhD	1	3.85
	Others	1	3.85
Professional Qualification	Engineer (Ir.)	5	19.2
	Architect (Ar.)	5	19.2
	Technologist (Ts.)	1	3.85
	Certified Safety and Health Officer	7	26.9
Years of Experience	Between 10 and 15	15	57.7
	Between 16 and 20	5	19.2
	More than 20	6	23.1

Practitioners were introduced to the PtD competency attributes identified in the initial work of this project (See Che Ibrahim et al., 2020). Next, these attributes were discussed in detail in relation to participants' experience in OSHCIM projects. The focused discussion also enabled the research team to explore an in-depth understanding of the context of these attributes (e.g., adequacy, practicality, and relevance) of PtD practice. To analyze the qualitative data, initial coding was carried out by considering the descriptive terminologies used by interviewees during the FG discussions. Then, thematic analysis was conducted using a structured coding scheme to relate the attributes of PtD competencies.

4.0 RESULTS AND ANALYSIS

This section presents the data extracted from the FG discussion. The insights reached were synthesized and integrated into a descriptive structure comprising three main competencies attributes: knowledge, skills, and experience. Table 4 presents an example of quotation classification based on the coding scheme.

Table 4 Sample of Comments Based on the Coding Scheme

Quotation	Source	Theme Context	Theme Category
"Designers need to have a full cycle of experience, from design until the maintenance, to have more knowledge on PtD"	Project Manager	Construction Design feature Management concepts Managing contract document Dynamic of the design process & construction practice	Knowledge Experience
"Designers need to have a specific level of experience in handling projects"	Consultant	Design	Experience
"Experience in construction could help designers visualize potential safety risks"	Consultant	Construction practice	Experience
"The use of project delivery influences the way teams work on PtD practice, with a traditional approach, we don't have contractor input at the beginning, we rely on the experience of designers to prepare and do the hazard analysis"	Safety and Health Officer	Project Delivery Experience Hazard recognition Skills	Knowledge, Skills, Experience
"Designers should receive early education as traditionally all OSH activities are done by contractors"	Safety and Health Officer	Early education	Knowledge Experience
"Designers have to understand the relevant guidelines as they needs to ensure compliance with all relevant requirements at the beginning stage of the design"	Consultant	OSH and PtD-related regulations / guidelines	Knowledge
"OSHCIM practice is not one or two weeks' work, it's throughout and after the project. Financial implications should be seriously considered"	Project Manager	Financial / Cost Benefits analysis	Skills
"We normally think about the construction costs, but we believe having some kind of cost-benefit analysis that can be geared toward upfront costs rather than later costs would be extremely useful"	Cost Manager	Financial / Cost Benefits analysis	Skills

The FG discussions also highlighted the importance of being equipped with financial-related skills and knowledge to be able to exercise financial skills such as cost-benefit analysis, life cycle costing, and risk assessment, and therefore guide decision-making in the context of PtD adoption. Although cost is perceived as a major barrier among local practitioners (Che Ibrahim and Belayutham, 2020), evidence from this pilot project indicates that cost control can still be achieved despite the implementation of the PtD. The most important aspect is the ability to provide a quantitative rationale and the ability to provide alternative solutions that can provide cost savings over the life cycle of a project (particularly during maintenance). These skills could also help PtD practitioners track the costs and benefits of PtD interventions over time. This is supported by several studies (e.g., Dharmapalan et al., 2015), where construction activities may have an impact on a wide range of risks, resulting in uncertainty about the associated costs, and the ability to conduct such an analysis (e.g., cost of accident prevention) could facilitate our understanding of the economic impact of PtD.

Upon further observation, greater collaboration (e.g., in terms of co-location during the design phase, spending more time in the design phase, and developing trusting relationships) is also visible during the conduct of pilot projects. Project teams spend more time discussing the design regarding risk and hazard identification compared to traditional design exercises. As such, collaborative skills are crucial, as the integration of different forms of expertise in PtD contexts could create unique solutions that lead to innovation, thus achieving the goals and aims of a project (Gambatese et al., 2017). Overall, technical and collaborative skills are essential for designers who wish to implement PtD. By developing these skills, designers can help create safer, more cost-effective, and more sustainable construction projects.

4.3 Experience

As the pilot OSHCIM projects are the initial exercises by the DOSH to provide practitioners their first actual practical experience of PtD practice in Malaysia, practitioners are expected to have little experience on the conduct of PtD practice (in particular on risk analysis, OSH documentation, etc.) is expected. As highlighted in the FG discussions, design experience is not a significant issue; however, on-site experience is critical for designers to enhance their capabilities. It is worth noting that all the OSHCIM pilots are building-type projects; hence, the participants' experience is limited within this scope. Experience managing different types of projects (including infrastructure) could enhance the dynamism of designers' capabilities for dynamic design processes (e.g., the complexity of a project could lead to extensive design changes) (Larsen and Whyte, 2013).

While pilot projects offer a platform for collaboration and cooperation between designers and builders (to integrate constructability issues), the reality of the local construction industry is the opposite. The lack of collaborative procurement is cited as one of the main barriers for the industry in creating a collaborative environment. Another concern is the lack of advanced contract procurement to incorporate PtD practices. Experience in such an environment could encourage designers to work collaboratively (inter- and intra-organizationally), contributing to the expansion of their competence toward improving construction processes and safety performance (Manu et al., 2019).

The need for PtD experience in tertiary education is another topic that was discussed. As OSHCIM is set to be mandated in the coming years, there is a significant need to establish PtD knowledge during tertiary education. Such educational learning experiences could shape the interpersonal skills and mindsets of future designers toward design thinking and a preventive culture. Appropriately educated designers can ease the need to perform the required duties as stipulated in OSHCIM.

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5. CONCLUSIONS

Drawing from the "experience" of practitioners' involvement in OSHCIM pilot projects, it can be concluded that the need for PtD-related tacit and explicit knowledge, PtD-related technical and collaborative skills among construction stakeholders, and PtD-related experience are crucial to the fulfillment of designers' duties, as set out in OSHCIM. Although this study is only a snapshot of PtD competencies in the local context, the findings fill a 'knowledge gap' that the industry needs to enhance its competencies to facilitate the development of PtD activities.

This study was limited to the views of experienced OSHCIM practitioners regarding the three main attributes of PtD competencies. Consequently, the findings do not represent the views of the entire construction industry. Future efforts could focus more on the practical activities (e.g., design risk reviews, OSH documentation, and financial implications) involved in OSHCIM pilots as part of capturing the lessons learned and best practices to further enhance existing PtD guidance in the local construction industry.

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