SHAPING THE FUTURE OF PREVENTION THROUGH DESIGN (PTD) PRACTICE IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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The Prevention through Design (PtD) Is an emerging safety practice in the construction industry. In Malaysia, Occupational Safety and Health in Construction Industry (Management) (OSHCI(M)) Was launched in 2017 to guide the construction stakeholders to explicitly consider the safety during the design phase and "design out" risks and hazards over a project's lifecycle. As part of a wider study to understand the extent of PtD implementation in Malaysia, this paper aims to discuss what it takes to drive the PtD implementation in line with the OSHCI(M). Qualitative data were collected from civil and structural engineers in Malaysia through focus group discussion based on four series of PtD workshops. From the analysis, three main elements were highlighted, notably the external forces, industry dynamics and operational organisation factors; as push factors that could influence and drive the success of PtD implementation in Malaysia. The findings provide a basis for discussion, both nationally and internationally, to gain greater understanding on driving the fulfilment of OSHCI(M). This study extends the PtD literature in construction context, in particular in developing countries, but also provides insights to interested parties into the advancements to the successful safer design consideration in the construction industry

Keywords: safety, engineers, PTD, H&S, Malaysia

INTRODUCTION

The issue of occupational injuries and fatalities is well acknowledged in construction worldwide. One of the possible contributors to the construction accidents and injuries is the design decisions made in the early phase of the project (Behm, 2005; Tymvios and Gambatese, 2016). Several studies (e.g. Behm, 2005; Haslam, 2005; Driscoll *et al.,* 2008; Hui, 2015) Based on data from the U.S., Europe, Australia and Singapore showed that between 27% and 60% of construction fatalities linked to design-related factors. Consequently, this phenomenon has led many governments to initiate new initiatives to regulate and/or encourage designer to participate in collective responsibilities of the workers and end-user safety.

The *Prevention through Design* (PtD) Concept, also known as design for safety (DfS) Or Safety in Design (SiD) Is one of the prominent ways of leading the fundamental shift of safety practice resulting in greater emphasis on designing out or minimising

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hazards and risks early in the design process (Gambatese *et al.,* 2017; Manu *et al.,* 2018a). The perceived PtD benefits has led to many countries to actively promoting the use of PtD practice in the construction industry.

In Malaysia, attempts to introduce the PtD practice has been initiated by the Department of Occupational Safety and Health (DOSH), under the Ministry of Human Resources, through the establishment of Guidelines on Occupational Safety and Health in Construction Industry (Management) (OSHCI(M)) In early 2017. Established based on the integration of the PtD principles, the guideline embraces the "from the cradle to the grave" concept (i.e. considers the total life span of a building or structure - from the initial concept, design, construction and usage until its demolition) And deemed to be enforced in the coming years.

It is worth highlighting that, the fact that the PtD implementation is part of the objectives outlined in the Construction Industry Transformation Programme (CITP) 2016-2020 under the Quality, Safety and Professionalism thrust: "Initiative Q2b: Improve level of occupational safety and health at construction site", the understanding on what it takes to drive its implementation is significant. If not properly understand, the industry will face significant challenges to diffusion and perceived risks to its implementation (Toole and Gambatese, 2016). *Such risks and challenges include lack of interest from client and designers, lack of safety knowledge among designers, fear of construction liability, conflicts with contractual and procurement arrangements and too many competing priorities during design phase (Tymvios and Gambatese 2016; Toh et al., 2017; Gambatese et al., 2017).*

Despite there were widespread examples of PtD studies and its implementation in various countries (Toole et al., 2017), majority are focused on developed countries and very limited for the developing countries (Manu *et al.,* 2018b). *This is an important gap in the research and practice that has led to barriers in understanding the PtD subject in construction within the developing countries. Given the current limited application of PtD in Malaysia, also of interest are ensuring effective implementation of OSHCI(M), it is important to understand the opinion of all stakeholders, including civil and structural (C&S) Engineers. Being the dominant designers in construction industry in Malaysia, efforts to understand the opinion of C&S engineers cannot be ignored as they are one of the key professionals that responsible to safety and health (according to BEM Code of Conduct of the Registration of Engineers Regulations 1990) And would contribute towards OSHCI(M)'s development and transition in the construction industry. In addition, their role (ensuring the effectiveness of the design and its constructability) in all stages of engineering and construction projects is significant (Toole, 2005).*

Therefore, this paper aims to discuss what it takes to shape the PtD implementation in line with the OSHCI(M). This study is part of a wider study to understand the extent of OSHCI(M) Implementation in Malaysia. *Gaining an insight of how PtD should be drive forward from the designers will facilitate the government and authorities in the dissemination of PtD across the country where formal PtD implementation in construction is gathering pace.*

Emergence of PtD in the Malaysian construction sector

In Malaysia, the Occupational Safety and Health Act 1994 (OSHA) And Factories and Machinery Act (FMA) 1967 is known to be the safety legislative framework for the construction industry. In addition to these legislations, guidelines related to construction safety practices (e.g. Guidelines for Public Safety and Health at

Construction Sites, 2007, Guidelines for the Prevention of Falls at Workplaces, 2007) Have also been established to prevent and control occupational safety and health at construction sites.

Nevertheless, compared to other industries, the construction industry has been documented as having large percentage of fatality rate (i.e. 585 workers were killed at construction sites, between years 2011 and 2016 (Department of Occupational Safety and Health (DOSH), 2017)). Having a disproportionate fatality rate represents a significant threat to the industry's sustainability as well as the business value to construction organisations. Thus, the need to have new initiatives on safety practices in the industry is significant in order to enhance the standards of safety in the construction industry. In particular, the positive impact of PtD practices have led to changes in safety practices and regulatory frameworks of construction safety in Malaysia. The efforts to introduce the PtD practices in the construction industry has started in the early 2017 by the Department of Occupational Safety and Health (DOSH), through the establishment of Occupational Safety and Health in Construction (Management) (OSHCI(M)) Guideline.

It is worth highlighting that the establishment of OSHCI(M) Would add value to the existing Occupational Safety and Health (OSHA) Act 1994 in securing and reducing the discrepancy of responsibility and accountability in compliance to safety guidelines between construction stakeholders. The guideline serves as a guide for individuals with legal duties under sections 15 (General duties of employers and self-employed persons to their employees) And 17 (General duties of employers and self-employed persons to persons other than their employees) Of the OSHA 1994 and further defines their role in compliance with the safety law.

While some countries (e.g. UK and Singapore) Have mandated the use of PtD in their workplace safety legislations, the recently established OSHCI(M) Guideline in Malaysia is based on voluntary approach (similar to the US and Hong Kong) Although is deemed to be enforced in coming years. This would provide ample of opportunities for design professionals in the construction industry to prime themselves with the new requirements and at the same time, acquire knowledge in controlling hazard and risk in the early stages of construction.

The evolution of PtD literature in construction

Research in PtD practice, in particular in the construction domain, has gained increasing attention over the past decades. To identify the literature, we used Scopus databases to search for all publications whose topics cover at least two keywords from the following search string: design for safety"; "safety in design"; "prevention through design" and "construction". In addition, we also referred to the list related to PtD literature (up to June 2016) Compiled by Tymvios (2016). Then, we cross-checked both sources in order to capture the relevant PtD studies in construction context. To trace the patterns and trends, we split the time into five sub-periods and summarise its study context and focus based on its publication year.

The early literature (sub period < 2000) On PtD have emerged from Lorent (1987) Who found that one of the main causes of accidents in construction is the upstream factors (i.e. design activities). The abovementioned report formed the foundation for Council Directive 92/57/EEC to instruct all EU members to focus on the statutory of safety and health in the design process. Research moves from the PtD concept to a wider scope which includes issues such as legal implications, the role of designer and PtD tools. Studies in this period mainly focus on European and US settings.

In sub period (2001 - 2005), the research has broadened its landscape from PtD concept to more empirical-based studies to provide evidence (e.g. linking of fatalities to the design activities) On the PtD practice in construction. Studies begin to focus on diverse subject (e.g. the insurance issue, regulatory / policy issue, Stakeholder (owner / designer), accident causation and PtD education) Through the use of variety methodological approaches. Apart from European and US settings, articles had extended to examine in UK.

In the third sub period (2006 - 2010), the research expands to consider the multiple context in understanding the PtD practice. Scholars begin to examine the impact of PtD on safety standard, role and responsibilities of civil and structural engineers towards PtD and the influence of procurement arrangements on PtD practice. This period also sees the National Institute for Occupational Health and Safety in US began its National Initiative on PtD and in the UK, the CDM Regulations gets its second revision in 2007. Articles begin to examine in Australia setting.

In the fourth sub period (2011 - 2015), the landscape of PtD research has broadened with more analytical-based studies that have provided evidence on the application of PtD in the construction industry of various countries. In particular, there has been a growing research interest on PtD in Australia, UAE and Denmark. In this period, new lines of research have emerged, where scholars have begun to focus on the effect of PtD on social sustainability and the application of tools to be integrated with safety in design practices.

In the fifth sub period (≥2016), more empirical studies aimed to enhance the understanding of PtD among different construction stakeholders in several countries began to develop. In Singapore, since the enforcement of Design for Safety (DfS) Regulation in 2016, studies such as Toh *et al.,* (2017) Have focused on exploring the DfS KAP for multi-stakeholders in the construction industry. In addition, much work in developed countries has also been done in different contexts such as; designers' behaviour on safety in the UK, generating interest for PtD, motivation for PtD and barriers to PtD diffusion. This period also sees the increase in studies conducted in developing countries such as Manu *et al.,* (2018a) And Manu *et al.,* (2018b) Who examined the awareness and practices of DfS amongst architects within the construction sector of Nigeria and Ghana, respectively.

In summary, findings from the construction literatures have widely acknowledged that the subject of PtD is still growing and receiving significant attention (for the last three to five years) In the international prominence (perspective from different stakeholders and different context), although the concept has been introduced over the past few decades. Despite the significant change and improvement in design activities across geographical boundaries over the recent years, there is still a lack of effort to contextualise PtD in the local construction context. As emphasised by Manu et al., (2018a), any empirical studies related to PtD in developing countries (e.g. Malaysia) Would be useful to advance the PtD knowledge within the construction domain.

RESEARCH METHOD

This study was performed in 2018 and first quarter of 2019, as part of an intervention programme initiated in collaboration with the Social Security Organisation (SOCSO) Malaysia, Department of Occupational Safety and Health (DOSH) And Construction Industry Development Board (CIDB) Malaysia. In line with the study's interest in obtaining an overview of a phenomenon, in this case, the key drivers for PtD

implementation in Malaysia, a pragmatic methodological approach through a qualitative method, in particular discussion forums through workshops was adopted. The adoption of the pragmatic approach would be most suitable as having a group discussion (i.e. meeting of a community of practice) Could produce results that can be translated into practical ends (e.g. exploring the drivers to enhance the PtD implementation in the construction industry). Moreover, having workshops as a platform to gather the data collection is possibly the best way as it will enable a greater degree of interaction with participants and also helps in setting expectations. Gathering a group of experts through a workshop in a collaborative and structured atmosphere could assist the engagement with participants who share a common domain and have expectations to achieve something related to their own interests, in this case is the PtD implementation (Gibson and Whittington. 2010; Ørngreen and Levinsen, 2017). It is worth noting that the PtD workshop is believed to be the first of its kind organised in the industry (since the introduction of OSHCI(M)), in collaboration with the regulatory bodies (i.e. DOSH and CIDB) That provide direct consultation and dialogue with C&S professionals.

Four series of PtD workshops (were held on 25th April; 8th and 25th August 2018; and 19 February 2019) With a total of 70 C&S engineers (on average of 17 participants per workshop) Were conducted as a platform to gather data. The purposive sampling of C&S engineer was adopted in this study as the focus of the initial PtD engagement with industry is with the dominant designer in the local construction industry. From the 70 participants, 58% of them described their job functions as engineer and senior engineer, followed by associate director (17%), director (16%) And engineer / OSH practitioner (with certified safety officer) (9%). It is worth noting that 75% of the participant were registered as Civil and Structural Professional Engineer under the Board of Engineers Malaysia (BEM) And the Institute of Engineers Malaysia (IEM). The participants (age ranging from late 20s to 56 years; mean 38 years old) Comprised of 81% (57) Male and 19% (13) Female. In terms of years of experience in the construction industry, the majority of participants had experience between 11 to 20 years (39%). Thirty-four per cent (34%) Of participants claimed to have experience of at least 10 years. This is followed by respondents (17%) Who had experience between 21 and 30 years; and ten per cent (10%) Of the participants had more than 31 years of experience in the industry.

Each workshop was structured with five presentation sessions and one discussion session. The first session was on the introduction of OSHCI(M) (presented by DOSH officer) And the next four sessions were related to PtD modules (presented by four different speakers (two academics with PhD degree in construction; and two academics are certified professional C&S engineers); Module 1: Overview of PtD; Module 2: Processes of Integrating Design and Risk Management; Module 3: Good Design Practices; Module 4: Tools and Resources to Support OSHCI(M) And Health and Safety File). Apart from presenting the relevant contents of the respective module, any questions and issues raised (during the first five sessions) Were noted down. Some of the issues raised (e.g. on the existing culture and behaviours, contracts, best practices, etc.) During the presentation sessions were put forward to the discussion session in order to have an in-depth insight on the matters.

The focus group discussion was conducted at the end of each workshop (last session) And lasted about an hour with the theme of 'shaping the future of PtD practices in the construction industry' in order to capture the C&S engineers' opinion on what it takes to successfully implement PtD in the local construction industry. Each discussion was

coordinated by a facilitator who was from the research team. All the relevant opinions and comments were noted down and analysed in order to realize any differences and commonalities of the findings.

RESULTS AND DISCUSSION

It is evident from the results that despite the early notion among participants that PtD is relatively new concept for them, several areas of commonality were observed and raised by participants in the discussions. The participants' views and thoughts were summarised under three common themes.

External Factors

The first theme identified was the influence of external factors in shaping the PtD implementation. One of the most cited sub-factors in this theme is the PtD education itself. Majority of the participants indicated that although they may have learned the related knowledge on the PtD concept (mainly through their lesson learned and experiences), arrangements to include the subject of OSH in general and PtD concept (e.g. risk, constructability) In particular, should be made during the early professional education i.e. bachelor degree in related civil engineering and built environment courses. It is worth noting that the Engineering Accreditation Council (EAC) In Malaysia dictates that all civil engineering degree programs must demonstrate the graduates meet the 12 specific program outcomes (POs) Where two of the outcomes (PO 3: Design/Development of Solutions and PO6: The Engineer and Society) Explicitly includes the term 'safety'. Nevertheless, based on feedback from participants (professional engineers who experienced as a panellist by EAC) Who have been involved with the accreditation process indicated that the incorporation of safety as a standalone subject is remain elusive. If included, the safety subject is mostly incorporated as a sub topic in a subject such as engineers in society, construction law and only covering the generic context of safety legislation and organisational safety management. The lack of OSH and risk management subject across Malaysia's tertiary education is apparent (Azmi and Mohd Saidin, 2013; van Dijk *et al.,* 2015) And embedding the PtD philosophy in a more widespread education is crucial and central (Toh *et al.,* 2017), as an effort to embrace and correct the fundamentals of PtD knowledge and attitude, not only for future C&S engineers but for all professionals.

Considering the lack of PtD knowledge as well as the awareness of the OSHCI(M) (based on the participant observation throughout the workshops), there is a need for more wider reaching programmes in order to reach-out to the C&S communities. With encouraging interest of acceptance among the participants, continuous PtD training (start with clear, simple and practical modules) Across all key designers is desirable, as an avenue for practical guidance towards enhancing the PtD knowledge and practice (e.g. risk management, communication techniques, hazards control, safety tool and file, etc). The inclusion of lesson learned from real case studies on the impact of PtD and the best practices should be incorporated during the training. Some of the participants recommended that for a start, introductory course (physical or online) Should be introduced as part of the initiative to increase PtD awareness and understanding among the designers. A growing dialogue between clients, constructors and designers on PtD is also preferable (e.g. enhancement of PtD community) As it could offer benefits to all stakeholders on the understanding and improvement of relationship towards PtD practices over time. This is to create a stimulating environment that creates a momentum for a paradigm shift (especially on cultural and

behaviour) In the current industry, towards the adoption of PtD, subsequently the OSHCI (M).

Another sub-factor identified was institutional pressures (e.g. originates from both formal rules (regulations, mandates) And informal constraints (norms, conventions, beliefs)). These pressures could influence the behaviour of project clients/owners and could extent to project-level PtD adoption. Based on the feedback, the participants claimed that project owners/client could play a major role in advocating this practice since they hold the power to control (i.e. operational) And fund construction projects. In addition, formal engagement with professional bodies (i.e. BEM and IEM) Is also highlighted as important process in order to ensure the support from the engineer's board. Any negative responses from the board would discourage the designer to adopt and adapt the practice. It is worth noting that the consideration to legally enforce the use of PtD has already been proposed by DOSH to be implemented in coming years. This effort is important as without legal enforcement, establishment of the PtD duty of care for designers and their responsibilities loses its potency (Kamardeen, 2015; Manu *et al.,* 2018a). The regulatory bodies (e.g. CIDB, DOSH and BEM) Have also explored other initiatives including mandatory completion of an OSHCI(M) Course as a registration requirement for professional designers. In addition, the professional assessment and competency examination could potentially be expanded to include the PtD context.

Industry Dynamism

The second theme identified was industry dynamism. There is widespread recognition that existing contractual and procurement framework is insufficient to embrace the collaborative and collective movement (e.g. PtD, BIM) In the industry. One of the most significant feedbacks from the discussion was that despite the existing OSH BQ in CIDB, (Guideline for OSH specification's schedule of prices), Public Works Department (PWD) (specification for OSH for Engineering Works 2011), DOSH (Guideline on contract management) and on-going development of standardised OSH BQ for government projects to improve the aspect of cost for safety, the issue on designers' liability insurance coverage, remuneration and professional fees still remains a significant concern to the designers. Such standard or contract could help to further develop the boundaries and the functions of safe design practice.

On the procurement side, the lack of contractors' involvement in design phase is highlighted as one of the main barriers for PtD implementation. The introduction of more collaborative procurement approaches (e.g. partnering, alliance and early contractor involvement) Is vital to help the industry players to embrace the collaborative movement towards positive PtD attitude and practice. The adoption of advanced procurement system will enhance the boundaries of safety roles and responsibilities at all hierarchy levels (Larsen and Whyte, 2013). Past studies (e.g. Toole *et al.,* 2017; Tymvios and Gambatese, 2016) Suggest that the ability to establish appropriate contractual arrangements will ensure the potential benefits (e.g. access the constructability at early stage, integration of safety among actors, clear about liabilities, contract terms etc) As PtD implementation would be maximised successfully.

The subject of having a single point of responsibility (i.e. independent coordinator / consultant) To manage the PtD implementation (e.g. the same experiences with Singapore) Has also been raised during the discussion as this approach could change the dynamic safety capability within the industry. While some of the participants

believed that this approach will create a new kind of employment with new lines of safety responsibility (with PtD professional certification), as well as ensuring systematic and comprehensive PtD implementation, while others have indicated that principal designers in the project should be the ones shouldering the responsibility. Moreover, local designers *would require specific safety knowledge about equipment and methods used in their geographic state to in line with any safety rules under Uniform-Building-by-Law (UBBL).* The reliance on independent consultants will revert the process back to the old safety culture, instead of moving forward towards proactive actions of PtD.

Operational organisation factors

The third theme was operational organisation factors, where the majority of participants pointed out that the use of digital application such as Building Information Modelling (BIM) Is one of the critical success factor for PtD implementation as it could alter the construction terrain and create new opportunities for improving productivity and safety at the early stages, and hence holds significant potential for supporting the fulfilment of OSHCI(M). Similarities in the aims of OSHCI(M) And BIM are self-apparent. For example, information on client or authority's requirements or specifications could be incorporated into designers' BIM model (digitally connected to the design engineers) And construction simulations could open-up the potential for identification, coordination and facilitation of health and safety checks and requirements. Such tools could assist the design decision during the planning and hence maximizing the safety of worker during operational phase (Toole, 2005). Moreover, as BIM level 2 has been introduced as a requirement for all government construction projects (valued more than RM 100 millions) By 2019, the collaborative effort towards enhancing safety practices is timely.

The subject of enhancing capacity building within the organisation has also been highlighted due to the fact that PtD is a new practice in the industry. One of the most cited factors is the lack of support and encouragement from the organisation to support the safety exercised during the design process due to other priorities. This scenario indicates the lack of awareness and capability of the organisation with regard to the safety aspect. Nurturing the safety capability through education and continuous training (Tymvios and Gambatese, 2016; Toh *et al.,* 2017) Is critical in order to build a risk sensible culture at all safety decision making levels. In addition, ability to monitor the capability and capacity of the organisations for PtD implementation over time is also vital for continuous improvements. Having such culture and capability could shift the organisation from the compliance approach to a more proactive and leading approach.

Overall, it can be seen that industry practitioners enrich the way forward for PtD implementation in more practical manner in order to suit the local context. In fact, despite that the concept is relatively new to the industry, they broaden the driver to include not only issues such as related to technological and legislative perspectives but also softer or non-technical aspects as the drives of PtD practice.

CONCLUSIONS

This paper has identified how *the PtD practice can be put forward for better implementation in line with OSHCI(M) In the local construction industry, based on studies of opinion from C&S engineers through three series of group discussions. In general, the practitioners agreed that PtD is a feasible intervention practice that need*

to be introduced as part of collective movement in improving the safety and health of workers.

The finding generates insights on the key elements for PtD diffusion, notably the external forces, industry dynamics and operational organisation factors. The first element, external forces, is related to early PtD education, platform for continuous engagement and institutional pressures. The next dimension, industry dynamics is focused more on the influence advance contractual and procurement framework as well as having PtD coordinator. The last dimension, operational organisation is related to the availability of PtD tools that would enable the PtD practice and nurturing the organisational PtD capability. By paying attention to these elements, it is possible for the regulatory bodies and construction organisations to instil positive safety practices among the C&S engineers, towards a paradigm shift of impacting the safety performance in the construction industry (i.e. Construction Industry Transformation Programme (CITP) 2016-2020 under the Quality, Safety and Professionalism thrust: "Initiative Q2b: Improve level of occupational safety and health at construction site").

Nevertheless, in acknowledging that the key elements are contextually embedded and only based on small number of population, further research could expand the current population to larger scales with diversified samples (e.g. clients, architects, developer, contractors) As well as focusing on qualitative methodologies (e.g. focus group, case studies) To facilitate more practical and informative findings in *understanding the impact of PtD practice towards the fulfilment of OSHCI(M).*

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