INTEGRATING PREVENTION THROUGH DESIGN (PTD) INTO ENGINEERING CURRICULA

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For many years, the National Institute for Occupational Safety and Health (NIOSH) and construction safety experts have advocated for implementing the Prevention through Design (PtD) concept in the United States. PtD aims to eliminate construction hazards during the design phase to prevent or reduce occupational injuries, illnesses, and fatalities during the construction phase. PtD is achieved by incorporating prevention considerations into all designs that may impact workers' safety. Civil and architectural engineers are considered the primary initiators of PtD in the construction industry, with the ability to educate project owners and construction practitioners about its benefits and importance. However, this group has a few, if any, educational interventions or training opportunities to develop PtD knowledge and skills in the United States. As a result, faculty members who may be willing to teach the PtD concept in their design courses (e.g., concrete, steel, foundation and traffic design courses) have limited exposure to the PtD concept and no clear guidelines to integrate PtD into their courses. This study surveys engineering department chairs in the United States to assess their perceptions about integrating PtD into the engineering curriculum. The findings showed that most participants do not favor incorporating PtD as a standalone course in the engineering curriculum. However, they expressed their support for integrating the concept as small modules within existing engineering design courses. Faculty members, teaching engineering design, should be provided the necessary resources to achieve this. This study contributes to our understanding of PtD integration strategies within engineering programs.

Keywords: Engineering curriculum, Construction safety, Construction hazards, Civil engineers.

1 INTRODUCTION

The ability to effectively influence safety is during conceptual and preliminary design phases before construction starts (Szymberski 1997, Lingard et al. 2015, Karakhan et al. 2018). According to Behm's research in 2005, 42% of the fatal incidents reviewed could have been avoided or resulted in less severe injuries if safety measures had been considered during the design phase (Behm 2005). Safety-focused educational design strategies are not systematically integrated into the civil and architectural engineering curricula in the United States. As a result, adequate and effective educational interventions designed specifically for civil and architectural engineers are lacking. The National Institute for Occupational Safety & Health (NIOSH) has developed four educational
modules to promote PtD and explain its motivation (NIOSH 2014). Yet, the effectiveness and adoption of these modules in engineering curricula have never been assessed (Jin et al. 2022). In several countries, including the United Kingdom, Spain, South Korea, South Africa, Singapore, Australia, and New Zealand, engineering professionals must consider PtD as outlined in their respective legislations (Ibrahim et al. 2022). For example, building design professionals in the United Kingdom have been required to explicitly consider PtD in their designs since 1994 (Aires et al. 2010). Unfortunately, civil and architectural engineers are not taught the PtD concept in the United States (Toole 2017).

The majority of the civil engineering programs in the U.S. elects to maintain ABET accreditations. ABET works with member societies such as ASCE, academic institutions, and industry partners to ensure that engineers of tomorrow are well prepared. ABET considers ASCE as the lead society to develop program criteria for civil engineering programs, architectural engineering programs, and construction engineering programs. Currently, only the construction engineering program criteria includes requirements for the curriculum to include application of knowledge of safety. However, there are only 22 construction engineering programs in the United States, while there are 302 accredited civil engineering programs and 29 accredited architectural engineering programs in the United States. Thus, there should be more efforts to include safety in the criteria of civil engineering programs. Recently, ASCE’s Civil Engineering Program Criteria Task Committee (CEPCTC) has proposed changes to the civil engineering program criteria effective for the 2024-2025 accreditation cycle. The proposed changes include requirements for the curriculum to include the explanation of safety as one of the civil engineers’ professional attitudes and responsibilities. Specifically, CEPCTC suggests the following as an example of compliance with this new requirement: “Explain how the design has considered the safety of those who construct, use, operate, and maintain the design.” Based on the well-known Bloom’s Taxonomy that classifies students’ development outcomes into six classes ranging from the simple recollections of specific facts to integrating complex ideas, the explanation is the second level of development below apply, analyze, synthesize, and evaluate levels. Thus, the current suggested language in the civil engineering program criteria may prepare future civil engineers to explain the PtD.

Toole (2017) suggests that the engineering community will not incorporate PtD into the curriculum until it is mandated by ABET or another external entity. However, other drivers, such as ASCE's Code of Ethics and the National Society of Professional Engineers’ (NSPE) Code of Ethics for Engineers, emphasize the added value of incorporating the PtD concept. Mann (2008) reported a strong consensus on utilizing modules for introducing PtD into the engineering curriculum by educators in appropriate courses during the 2007 NIOSH workshop. Thus, securing the support of engineering schools was one of the NIOSH's plan elements in 2011 to implement PtD (NIOSH 2011). According to Behm et al. (2014), the NIOSH's PtD initiative includes a goal to "enlist the support of Deans of Engineering Schools to include basic PtD principles and occupational safety and health principles in required engineering courses." However, these elements have not been successfully tackled.

Occupational safety and health are critical aspects of all construction projects, and therefore engineering programs should incorporate PtD concepts into the curricula. However, to include PtD and workers' safety in engineering curricula, course modules, contents, materials, and other learning directives must be designed and assessed for use by engineering design faculty. Civil engineering faculty members specialize in various engineering subdisciplines such as structural, transportation, geotechnical, water resources, and construction. In general, faculty who teach engineering design courses, such as structures, transportation, geotechnical, and hydraulics engineering, have limited knowledge of construction means and methods or, thereby, their related
safety challenges. Accordingly, the availability of instructional resources would lower the barrier to implementing PtD by engineering design faculty. Therefore, there is a need to strategically tackle the PtD integration and ensure design faculty buy-in. This study aims to understand the barriers and drivers influencing PtD integration into the engineering curriculum.

2 METHODOLOGY

To achieve the study objective, an online survey was designed to understand the barriers and drivers that influence PtD integration into the engineering curriculum. The survey targeted the United States' civil engineering department chairs. The survey was administered in April 2023, and 29 valid responses were received. The engineering department of most participants was the Civil Engineering Department (i.e., 17), followed by the Civil and Construction Engineering Department (i.e., 5), the civil and architectural engineering department (i.e., 3), and other civil-related departments such as civil and environmental engineering departments.

3 FINDINGS

Most department chairs who participated in the study agreed that PtD is an important concept that future civil/architectural engineers should be aware of, as seen in Figure 1. However, the department chairs highlighted insufficient space within the engineering curriculum to introduce PtD as one course, as seen in Figure 2. As a result, department chairs felt it is more appropriate to introduce the PtD concept in small modules in engineering design courses. Accordingly, the result shows that department chairs are more willing to integrate the PtD in small modules within existing engineering design courses, provided that faculty members are equipped with the necessary materials, see Figure 3.

Figure 1. The department chairs agreement on the importance of PtD.

Figure 2. Curriculum flexibility to incorporate PtD as a course.
Accordingly, participants were asked to suggest courses that could be used to introduce the PtD concept. Participants suggested several courses, including Introduction to Civil Engineering, Structural Design, Construction Engineering, Steel Design, Foundation Design, and Capstone Design Courses. As for the main barriers to PtD integration, participants stated the following:

- “The curriculum is already packed with other topics.”
- “There are already many credits in the program - adding more is difficult.”
- “Faculty members are unfamiliar with the PtD concepts and how to include it in the design process (i.e., lack of faculty expertise). Adoption by faculty willing to incorporate PtD concepts into their courses with little knowledge of construction safety and the various hazards workers are exposed to daily.”
- “Lack of curriculum materials that are easily adaptable to their classes.”

At the same time, participants stated the following as drivers that would encourage the PtD integration into the engineering curriculum:

- “Inclusion in the ABET accreditation requirements would be a major driver. Another would be feedback from the industrial/professional Advisory Board from the program curriculum in their corresponding programs.”
- “Educating faculty about the issues of integrating PtD into the curriculum and providing educational materials.”
- “Dissemination of benefits from PtD practices - basically, "an ounce of prevention is worth a pound of cure” (Benjamin Franklin). When people realize that it can affect the bottom line and lives, then it is important. However, if it is taught as just another rule you must comply with, you do more harm than benefit.”

4 CONCLUDING REMARKS

PtD is a vital concept that can significantly contribute to safer work sites. Despite its importance, increasing the industry's utilization of the PtD concept seems challenging. In this study, the research team tackled the challenges that hinder the wide integration of PtD into civil and architectural engineering curricula across the United States. The department chairs who participated highlighted four strategies that can be used to integrate PtD into civil and architectural engineering programs effectively by providing a better understanding of drivers and barriers to PtD
integration. In the following sections, the authors elaborate on the four top strategies. Accordingly, scholars are encouraged to initiate a research agenda to address each one of them.

4.1 Small and Adaptable Educational Modules

The collected data suggest that it is infeasible to introduce the PtD concept into the undergraduate and civil engineering curriculum as an independent course. It can, however, be effectively implemented in many design courses as opposed to a stand-alone course. The curriculum is already packed with other topics, and limited time is available within the existing courses, even if time allocations toward other contents were reduced or replaced. Thus, introducing PtD in small and adaptable modules is the best strategy to overcome the time limitations.

4.2 ABET Inclusion

The PtD inclusion in ABET accreditation would be a major driver. This may be accomplished through the addition of PtD into the program criterion of the ABET criteria through the close engagement of the ASCE’s Program Criteria Task Committee. ABET accredited engineering programs are based on the general criteria and program criteria. General criteria must be satisfied by all programs in order to be accredited by ABET. There are 8 general criteria that need to be considered. These include: (1) keeping track of student progress, (2) setting educational objectives for the program, (3) documenting student outcomes such as their ability to identify, apply, communicate, recognize, function, develop, and acquire, (4) continuously improving the program, (5) ensuring that the curriculum covers enough content related to the program subject area, (6) having enough faculty members who are competent in their respective fields, (7) ensuring that the facilities are adequate, and (8) having sufficient institutional support and leadership. On the other hand, program criteria offer the necessary details for interpreting the general criteria in relation to a particular field. CEPCTC proposes civil engineering program criteria. Based on the discussion provided in the introduction, it appears that the CEPCTC is pushing for safety to be included in the ABET accreditation requirements, particularly in relation to the responsibilities and attitudes of civil engineers. This change is anticipated to be effective for the 2024-2025 accreditation cycle. One of the topics that faculty members can cover to demonstrate compliance is PtD. This movement will generate a significant need for educational material that can be easily utilized by engineering faculty members.

4.3 Faculty and Department Buy-In

Faculty acceptance and department encouragement is key in the integration process. Civil and architectural engineering faculty members, who should integrate PtD into their courses, are specialized in other various engineering subdisciplines such as structural, transportation, geotechnical, water resources, and construction. It is anticipated that a better understanding and introduction of the PtD benefits would help improve buy-in among faculty members. If faculty members realize how PtD can save lives, then the buy-in likelihood will significantly increase. It is not recommended to introduce the PtD concept as just another topic that faculty members should teach because OSHA recommends it. A similar strategy should be followed to secure department chair support. One of NIOSH's plans to implement PtD in 2011 was to secure the support of engineering schools (NIOSH 2011), but it appears that this goal has not been achieved yet.

4.4 Educational Materials

Faculty members who teach engineering design courses have limited knowledge of construction means and methods, if any. Therefore, it is unreasonable to expect them to introduce the concept
of PtD into their courses without first providing them with the necessary resources. Thus, there is a need to designing, developing, and refining course-based PtD educational modules. The creation of these modules will serve as the cornerstone of PtD education, helping to increase knowledge, skills, and awareness, regardless of whether ABET chooses to include safety in its requirements. The educational modules should be created by soliciting also include the programs’ advisory board for input related to design safety issues. Furthermore, introducing PtD concepts and/or training modules to civil engineering program industrial advisory boards can be another significant and impactful driver in promoting PtD to all constituents.

References


