



Rapporteur's Report

Research Issues in Prevention through Design

John A. Gambatese

School of Civil and Construction Engineering, Oregon State University, United States

Available online 18 March 2008

1. Introduction

Prevention through Design (PtD) research is central to the National Institute for Occupational Safety and Health's (NIOSH) national PtD initiative. Research is needed to support PtD efforts in all of the other three functional areas (Practice, Policy, and Education) and within all eight industry sectors. The PtD concept is new to many industry sectors. An understanding of how the PtD concept can be effectively implemented, and the resulting impacts and outcomes, is lacking in some industries and in need of fine tuning in others. Research will provide the opportunity to explore and gain further understanding of the concept, and evidence to support a national PtD initiative.

2. Focus Areas of Discussion

A breakout session on the second day allowed the workshop participants the opportunity to focus their thoughts on PtD research. To facilitate discussions during the breakout session, seven topic areas were presented that were developed based on input from the eight industry sectors on the previous day. The seven topic areas were:

1. The economics/business case for PtD
2. Design-related causality of occupational injuries and illnesses
3. The development of PtD devices, tools, and processes
4. Worker, machine, structure, and environment interaction
5. Diffusion, sustainability, and the communication of design innovations
6. Methodologies for PtD research
7. Leveraging PtD methods and technologies from other industry sectors

Participants in the breakout session were asked to consider each of these topics and to provide input and guidance for

conducting PtD research in these areas. Summaries of the discussions related to each topic are provided below.

3. Topic 1: The Economics/Business Case for PtD

Understanding the economics of PtD in practice is crucial to its acceptance and implementation. Designing and implementing a new process, product, or system involves consideration of many competing priorities. Much of the decision-making that occurs, for change to take place in an organization is based on financial considerations, and any change within an organization typically must be supported by a positive return on investment. Lacking sound financial support or a firm understanding of the financial implications, a good idea may not be realized in practice. Anecdotal evidence suggests that PtD can improve productivity, quality, and cost, however further research is needed to fully understand and quantify the economics of implementing PtD. A greater understanding of the impacts on these factors would allow for making a business case for PtD.

Research is needed that examines the costs associated with both the process of PtD and the manufacturing and construction of specific safe designs. The economic impact of not integrating safety early into the design process also needs to be investigated. Addressing safety issues through retrofitting has been shown to be quite expensive, but further documentation is needed. When economic evaluation is conducted at an industry-wide level, assessments should consider costs related to people, the environment, and social costs. Making a business case for PtD is usually done at the individual company level and should include both direct and indirect costs. There may be a situation where the business case study does not indicate a positive return on investment, while the societal economic evaluations suggest a benefit to society as a whole. Both types of analyses provide valuable insights into the PtD concept and are needed.

A complete understanding of the financial implications involves assessing the benefits of PtD as well. It is anticipated that benefits will accrue in terms of improved safety, higher productivity, and better quality. Developing and comparing an

E-mail address: john.gambatese@oregonstate.edu.

appropriate benefit-cost model would provide a means to assess PtD from a financial perspective. Conducting this research requires the involvement of economists, actuaries, legal advisors, and others who understand financial models, economics, and organizational behavior.

Part of making the business case for PtD, or any occupational safety and health intervention, involves comparing the present financial environment to one that would incorporate PtD concepts. When PtD is not implemented, cost-shifting occurs. That is, rather than funding the implementation of safety and health controls early on during design, the associated cost is shifted to downstream entities in the form of alternative hazard prevention measures, re-design of work following implementation, and additional worker healthcare and insurance coverage. Research to quantify these costs, and compare them to the costs associated with implementation of PtD, will help make the business case. Given that the financial environment may differ between small, medium, and large organizations, the studies should consider a range of organization sizes.

4. Topic 2: Design-Related Causality of Occupational Injuries and Illnesses

The goal of PtD is to prevent work-related injuries and illnesses. To do so requires an understanding of the connection between design features and occupational injuries and illnesses. This is a very important first step. Understanding injury and illness causality allows for analyzing and re-designing work environments, tools, and systems, to eliminate the associated hazards. The breadth and sophistication of designs within industries make this task difficult. Research is needed to determine how to effectively assess design-related causality and to determine the connection between specific design features and worker injuries and illnesses.

Better surveillance data on worker injuries and illnesses is needed. Data that indicate when, how, and why injuries and illnesses occur can then be used to identify design-related causes, and motivate design modifications to promote healthier and safer work environments, tools, and systems. Both the frequency and severity of injuries and illnesses should be considered when identifying new designs.

5. Topic 3: The Development of PtD Devices, Tools, and Processes

In many industries, hazard recognition is quite difficult given the complexity and size of the systems designed. Accordingly, implementation of PtD in practice is facilitated through the use of tools and processes that assist in the visualization of hazards, analysis of design options, and creation of new designs. The need for this assistance is great for designers who are less experienced and lack the requisite skills and knowledge required to recognize hazards and develop optimal designs. While some tools exist that can facilitate the design process, such as checklists and computer-aided design (CAD) systems, PtD research is needed to develop supporting design tools and processes. Additional tools and processes, which can be effectively applied in a wide range of

situations, are needed to assist with hazard recognition and design optimization.

Research is also needed to investigate and develop new designs that create a safe and healthy work environment. This effort starts with surveillance data to identify design-related impacts to worker safety and health. Using surveillance data and causality analyses, an inventory of current designs and the related hazardous properties could be created to target the research on specific design components. Research could then be conducted to create new designs that lack the hazardous properties. Including the views and input of the workers affected by the designs and the manufacturers of the products, is an important aspect of this research. Modular designs, light-weight assemblies, ergonomically beneficial tools, and low noise-emitting equipment are examples of beneficial designs. The designs should consider not only the controlling system, but also all sub-systems so that they are not negatively impacted. There are many ways to solve a problem and design a device, tool, or system. To encourage consideration and exploration of different designs, the research should not be limited solely to the *best* practice, but also include good, but imperfect, practices that may be more appropriate depending on the situation at hand.

6. Topic 4: Worker, Machine, Structure, and Environment Interaction

In addition to developing tools and processes to implement the PtD concept, and creating designs that eliminate worker injuries and illnesses, research is needed to understand how to account for human interaction with machines and their work environment when creating a design. The ways in which workers approach, operate, and view machines can impact the hazards that they experience. Workplace dynamics and organizational culture have also been shown to influence worker safety and health (Gyekye & Salminen, 2007). Research is needed to understand these impacts in the context of PtD, and can be accomplished through ethnographic studies aimed at creating and developing products and services that better meet worker needs. Once implemented, maintenance and durability of the tools and continuance of a positive PtD climate, is of concern. How to maintain PtD practices throughout the lifecycle of a project, or within an organization, should also be investigated.

7. Topic 5: Diffusion, Sustainability, and Communication of Design Innovations

Diffusing and maintaining the knowledge learned from PtD research and practice plays a significant role in its success. The large size, complexity, and fragmentation of many industries commonly make diffusion of information difficult without concerted communication efforts. Research is needed to determine what avenues are available to disseminate PtD information and to measure their effectiveness. This research should be followed-up by implementing successful communication strategies so that actual diffusion of the information occurs.

Research related to this topic should consider bringing in a global perspective. PtD is common to some industries outside the United States, and their experiences are valuable to understanding and implementing the concept. Researchers can look to these other successful initiatives to learn how best to promote and communicate PtD to a wide audience. Use of print media should be maximized, including: scientific journals, trade publications, websites, and newsletters. Dissemination of PtD concepts can perhaps be leveraged by connecting them to current safety and health initiatives or to related concepts, such as sustainability and green design. The use of industry leaders and first adopters to assist with dissemination of PtD concepts to other organizations should also be investigated. Additionally, models in one industry — such as The Center for Construction Research and Training's on-line tool, Electronic Library of Construction Occupational Safety and Health (eLCOSH), or the Safer Needles Used in Healthcare program — can be transferred to other industry sectors.

One means for effective communication is through case studies. Published studies of actual implementation of PtD provide a valuable, applied perspective to those considering the concept, as well as evidence of the benefits and associated costs. PtD case studies should be developed and include translational research to facilitate publishing research findings and educating researchers on how best to diffuse their work.

Demand for PtD knowledge is a strong enabler of diffusion. Providing the design community with an incentive to modify their designs to incorporate worker safety and health will create a demand for PtD knowledge. Lacking such a demand, the design community has no reason to change. The design firm must see a value in implementing the PtD process. Research is needed to explore what drives the design community to act and how best to create this demand. The research should involve worker organizations, educational institutions, compliance organizations, and professional groups associated with the design communities, to determine how each of these can affect the demand. Supporting resources, bidding and pricing requirements, contractual language, and monetary incentives are also means for creating demand and should be investigated.

8. Topic 6: Methodologies for PtD Research

Conducting PtD research is a complex venture. It often involves numerous stakeholders trying to study a new process and measure an outcome that may not be directly quantifiable. The presence of confounding variables related to sample demographics, other ongoing interventions, and uncertainty, make generalization of study findings to the overall population suspect. There is a need to establish PtD research methods that account for these factors and result in reliable research findings under practical research limitations and resources. These methods can include cause and effect studies of specific design interventions, or focus group interviews to evaluate worker perspectives and attitudes. Another example is a meta-analysis of the PtD concept to obtain overarching observations of PtD, and to address confounding factors that may not be possible in more focused studies.

Once new designs are implemented, evaluation of their effectiveness is necessary to determine the impact of PtD. Research is needed to: develop evaluation metrics, measure the performance of specific designs, identify benchmarks for safety and health performance, and assess the performance relative to the benchmarks. The metrics may include an aggregate of leading indicators that point toward PtD impact. It is often difficult, however, to access data needed to conduct such studies. Facilitating this data transfer requires industry support and involvement. Getting industry sectors involved in research can help to eliminate barriers to acquiring data and testing PtD concepts.

The research should consider performance not solely on worker safety and health, but also on other outcomes such as cost, quality, and sustainability. Claims history, Occupational Safety and Health Administration's recordable incidence rate, and other lagging indicators, may be used to measure performance, however leading indicators should be considered as well. A reporting system should be developed to create an efficient and consistent means for gathering and tracking baseline data. Because companies are often reluctant to share information that is deemed confidential or part of their competitive advantage, the research should consider how best to acquire the information and what is actually needed. One possibility for overcoming this obstacle might be to have companies pool the information for dissemination collectively without company identifiers.

There is a need to conduct simple, small studies that focus on specific designs. While these types of studies may not be groundbreaking or high profile research, they can contribute to a significant safety and health issue, and when combined, can provide a magnified impact. Efforts should be made to coordinate studies under a common funding program, such that they complement each other and combine to create a greater impact than each could have on its own. Collaborative research that involves multiple organizations and areas of expertise is a key part of ensuring comprehensive studies.

9. Topic 7: Leveraging Methods and Technologies from Other Industry Sectors

Innovation often occurs in an industry sector as a result of the integration of ideas, tools, and technologies from another industry. In some industry sectors, implementation of the PtD concept is just beginning, while in others its use in practice is more mature. Successful PtD models exist, as do knowledge of their performance, which can be drawn on by other industries. Research studies are needed to: expose existing PtD practices in each industry sector, evaluate the practices in terms of their transferability to other industries, and develop the practices for application in other industries. Conducting this research requires that connections be made between industry sectors to enable the communication and exchange of ideas and experiences. This could be accomplished by creating a national clearinghouse of PtD information. Access to such a clearinghouse would allow researchers to learn from other industries and keep from duplicating research efforts.

10. Barriers to PtD Research

The discussions regarding research also need to include exposed barriers that exist at the organizational and industry levels, and within the limitations of applicable research methods. The barriers to conducting PtD research that were identified include:

- the large size, complexity, and fragmentation of the industry sectors;
- difficulties associated with conducting occupational safety and health research;
- a lack of a standardized PtD research methodology;
- difficulties in analyzing safety and health hazards and identifying the design as a causal factor;
- perceived liability associated with PtD and an attempt to limit the liability;
- a lack of awareness and understanding of PtD;
- an absence of reliable data for analysis;
- the inability to obtain data because of confidentiality and competitive advantage issues;
- competing design priorities (e.g., cost, productivity, quality);
- an incomplete communication network for disseminating PtD knowledge;
- a lack of knowledge of the safety-related factors in business;
- a lack of PtD education and training for designers;
- difficulties in translating research to something that industry can understand; and
- the absence of a national champion for PtD research.

Overcoming these barriers requires that researchers, industry, and government agencies come together to plan and conduct the research. Participation is needed by all affected parties. In addition, sufficient funds and resources should be allocated that allow for in-depth examination of the PtD concept and its application in practice.

11. Conclusions

Moving forward to accomplish the identified research goals requires efforts on numerous fronts. Questions still remain regarding PtD's impact and the most effective tools for its imple-

mentation. Using previous and on-going research as the starting point, additional investigations should be conducted to validate the impact of PtD on worker safety and health and on other project properties. Since PtD knowledge may be incorporated into the design in various ways, assessing its impact should be conducted in conjunction with the development of processes and tools used for its implementation. Parallel efforts are also needed to educate and train design professionals to assist and promote the implementation of the design processes and tools. It is clear that without continued research and dissemination efforts, acceptance and implementation of the PtD concept in the industry sectors will not take place.

Comprehensive PtD research will require multiple studies over an extended period of time. Like in many other fields, occupational safety and health research is commonly conducted by independent organizations and researchers, who often work independently and occasionally in collaboration with others. Communication of investigative efforts, barriers, and findings takes place through publications, presentations, and in some cases, informal contact. The autonomous nature of research efforts, along with the often lengthy time period between performance and publication, can inhibit timely, comprehensive, interconnected research of a particular topic. Studies that are undertaken may overlap or result in knowledge gaps. Effective performance of PtD research can benefit from a concentrated effort that integrates and coordinates the individual activities of separate efforts. When a study is required on multiple fronts, this allows for planning and conducting integrated research and ensures that all needs are addressed without duplication of effort. Because of the many and varied PtD research needs remaining, such a combined effort is suggested for continued research on the topic.

Reference

- Gyekye, S. A., & Salminen, S. (2007). Workplace safety perceptions and perceived organizational support: do supportive perceptions influence safety perceptions? *International Journal of Occupational Safety and Ergonomics*, 13(2), 189–200.