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# How Emerging Professionals are Harnessing Tech to Build Safer Workplaces

One of the guiding principles of SHIFT and BCSP is our commitment to growing and empowering the next generation of EHS leaders. This commitment comes to life through outreach and education, introducing children to the value of safety from an early age, helping young workers understand their rights and responsibilities as they enter the workforce, and supporting those who have chosen to pursue a career in EHS as they begin their professional journey.

That commitment is reflected in the work of the BCSP's Emerging Professionals Committee (EPC). The EPC is made up of seven early-career professionals and two BCSP Board liaisons. Together, they meet to discuss the needs of today's EHS practitioners, where the profession is heading, and how we can all work together to shape its future.

In August earlier this year, BCSP hosted the Research & Innovation Summit—a biennial event that provides a unique forum for individuals and organizations dedicated to the advancement of EHS. Members of the EPC joined us for a roundtable discussion on what's new in the EHS industry and where there might be opportunities for future research. Technology quickly dominated the conversation. It's a topic that was readily discussed throughout the Summit and one that continues to be a driving force in how safety is evolving. As new technologies emerge, it's important to understand how younger safety professionals are embracing them to make our workplaces safer.

The EPC members shared several examples of emerging technologies they're seeing in their workplaces. One member's organization uses wearable devices to monitor body temperature in high-heat environments, an innovation that prevents heat-related illness in real time. Others spoke about incorporating virtual and augmented reality (VR/AR) into safety training to create immersive, hands-on learning experiences. While not yet in use at their sites, members also discussed the growing potential of robotics, particularly robot "dogs" capable of scouting for hazards before workers enter a job site. Additionally, exoskeletons, currently being tested in some industries, were highlighted as a promising tool to help reduce strain and minimize musculoskeletal injuries.

Also discussed were the advancements in radio-frequency identification (RFID) technology, where some of the newest systems no longer require workers to wear devices. Instead, the equipment itself can detect when someone's too close and automatically prevent a potential struck-by incident.
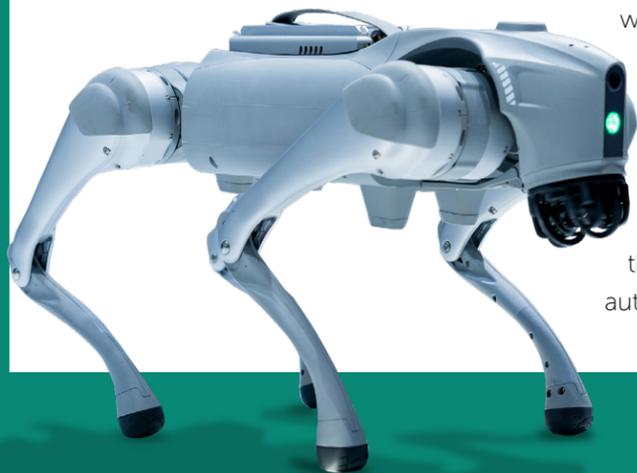
There continues to be a growing demand for technological innovation in safety training. Tools like VR/AR and microlearning allow us to simulate real-world scenarios—like operating heavy machinery or working at heights—without simulating real-life danger. These tools also help standardize training, making it easier to keep training consistent across an organization and helping ensure that everyone shares the same foundation of safety knowledge. Beyond EHS, industries like healthcare are using VR to study brain function and injury response, showing just how versatile this technology can be.

Another topic readily gaining interest in EHS is artificial intelligence (AI). Optimism amongst the EPC members was shared as they discussed AI's potential to enhance efficiency and elevate safety practices across the profession. They discussed how AI can streamline processes like new-hire onboarding and hazard predictions, giving safety professionals more time to focus on protecting people. The group also explored how AI's ability to collect and analyze large volumes of data can reveal patterns, predict potential hazards, and enable faster responses during emergencies. Real-world examples included the use of predictive analysis to assess worksite readiness and automated alerts for severe weather or fire events.

As we prepare to celebrate SHIFT's fourth year, we're grateful for the insight and energy the EPC continues to bring to our work. Their perspective helps us stay connected to what's happening in the field. Looking ahead, expect technology like wearables, body cameras, and smart surveillance to continue to grow, alongside a focus on worker-centered safety, human and organizational performance, and better frontline tools and equipment.

Finally, I want to take a moment to thank the members of BCSP's Emerging Professionals Committee. Their insight and enthusiasm play a huge role in helping SHIFT bring meaningful, practical research to the EHS community, and their voices remind us that the future of EHS is in good hands.

Angela Giotto, PhD, CSP
Managing Editor

Transitioning from Field Safety to Management: A Crucial Phase for Emerging Professionals

For emerging safety professionals, transitioning from a field-based role to a leadership position is both an exciting and challenging milestone. Moving into leadership is an important phase in many safety professionals' journeys, but what are the best ways to support early-career professionals as they make this change?

Field experience is the foundation of safety knowledge. It fosters practical understanding, strengthens hazard recognition, and builds credibility with frontline workers. However, when a professional moves into an office-based management role, the responsibilities shift from direct oversight to strategic planning, compliance management, data analysis, and leadership—requiring a different skillset and focus. This transition is not always straightforward and often challenges emerging professionals as their daily tasks shift and their role becomes more analytical.

From our own journeys and conversations with early-career professionals, three common challenges stand out:

1. **Shifting from Reactive to Proactive Thinking:** In the field, safety professionals often respond to immediate hazards. In management, the focus expands to trend analysis, policy development, and long-term risk mitigation.

2. **Developing Communication and Leadership Skills:** Management roles demand the ability to influence executives, lead meetings, and communicate across departments—a different skillset than field coordination.

3. **Maintaining Field Credibility:** It is crucial not to lose connection with field teams. Regular site visits, continuous engagement, and a willingness to listen ensure that safety policies remain practical and grounded.

Support during this transition—through mentoring, training, and leadership development—can make a significant difference. Academic resources like this one, and many others, also play a vital role in helping EHS practitioners advance their careers and step into management roles. By offering access to academic research, case studies, and best practices, these resources empower professionals to turn experience into expertise and take confident steps toward leadership.

The Emerging Professionals Committee is grateful to be part of this vital conversation. We hope the dialogue around this topic continues to grow, and by fostering these discussions, we can help shape and empower the next generation of safety leaders.

Emerging Professionals Committee at the 2025 Research & Innovation Summit in Indianapolis, IN.

Translanguaging as a Strategy to Enhance Safety and Workforce Training for Spanish-Speaking Adults in the Energy and Construction Industries

RICHARD HANNAH, PhD, MBA, ASP - rhannah@NCCER.com

JULIE MATUSZCZAK, PMP

SARA VERA, MA

YESENIA MAURICIO

ABSTRACT

As the demographics of the U.S. workforce evolve, especially in high-risk sectors such as construction and energy, so too must the strategies for delivering effective training. Despite the significant representation of Spanish-speaking workers in these industries, traditional safety and workforce training programs have historically been offered only in English. This has posed critical barriers to comprehension, retention, and safe on-the-job performance for many non-native English speakers. However, recent shifts in practice have begun to embrace more inclusive training methodologies, including translanguaging—an instructional strategy that integrates multiple languages within the learning process. This qualitative study examines the experiences of adult learners in Texas-based workforce programs that used translanguaging approaches to support safety training. Drawing on participant interviews and learner feedback, the study reveals how leveraging both English and Spanish improves engagement, knowledge transfer, and learner confidence. The findings offer practical implications for employers, trainers, and policymakers seeking to enhance safety outcomes and workforce development by addressing language diversity head-on.

INTRODUCTION

As the construction and energy workforce becomes increasingly diverse and multilingual, employers and educators face pressure to ensure that safety and skills training are understood by the learner. Historically, training programs in high-risk industries such as construction, energy, and manufacturing have not always served Spanish-speaking workers effectively. In these industries, although Spanish resources and bilingual trainers exist, many programs are still delivered primarily in English or rely on word-for-word translation, which can miss deeper linguistic and cultural factors and has been associated with confusion or increased injury risk (Brunette, 2004; O'Connor et al., 2005; Roelofs et al., 2011; Trajkovski and Loosemore, 2006; OSHA, 2010).

This language mismatch has produced profound implications. Hispanic workers, particularly those with limited English proficiency (LEP), have experienced disproportionately high rates of injury and fatality on jobsites (OSHA, 2021; Dong et al., 2011). Research indicates that when workers are not trained in a language they fully understand, critical safety information may be misinterpreted or overlooked entirely (Lipscomb et al., 2013). In response, training organizations in these industries have begun to expand Spanish-language training resources and explore more culturally responsive teaching methods.

One such method is translanguaging, which can be used to close this gap in comprehension and safety as well as allow learners to draw upon all their natural language resources (García and Kleyn, 2016). Translanguaging, coined by educator Cen Williams in the 1990s, is a pedagogy that originated in bilingual Welsh classrooms and was later developed into a widely used educational framework in applied linguistics (Lewis et al., 2012a). Unlike code-switching, alternating between two different languages, translanguaging provides learners with a strategically integrated repertoire to call upon (García and Li Wei, 2014). Rather than isolating English and Spanish as separate silos, translanguaging strategically blends the two to promote comprehension, critical thinking, and real-world application (Hesson et al., 2014; Li Wei, 2018; Lewis et al., 2012a). For adult learners in workforce development settings, this approach can support deeper engagement and safer performance, particularly in complex or hazardous environments.

This study examines the use of translanguaging strategies in construction and energy sector training programs for contractors in the Gulf Coast region of the Southern United States.

Findings provide insight into how bilingual instructional models using translanguaging can support not only literacy and comprehension but also potentially improve safety outcomes for linguistically diverse workers. As the workforce continues to evolve, embracing translanguaging may be an essential step toward a safer, more inclusive, and more skilled labor force.

LITERATURE REVIEW

What is Translanguaging

Translanguaging refers to the dynamic process by which individuals who utilize and understand multiple languages to varying degrees draw on all of their linguistic resources to understand and express knowledge (García and Wei, 2014; Vogel and García, 2017). Unlike direct translation, translanguaging embraces the fluidity of real-world language use and has been shown to improve comprehension and learner engagement in educational settings (García, 2023; Sayer, 2013).

Unlike direct translation, which seeks direct equivalence, or code-switching, which toggles between separate language systems, translanguaging assumes bilingual learners draw from an integrated system to make meaning, particularly when engaging in learning activities (Kampittayakul, 2018; García, 2023). Even though code-switching and code-mixing have long been recognized as valuable strategies for helping non-native English speaking (NNES) trainees, translanguaging represents a more strategic, integrated, and advanced approach to helping these learners. Code-switching is typically defined as alternating between two or more distinct language systems, often governed by social or functional cues (Sridhar and Sridhar, 1980; Myers-Scotton, 2000).

While code-switching can be limiting due to its socially driven and structurally bound nature, translanguaging can disrupt English-only training delivery as it allows learners to fluidly and strategically blend languages for deeper comprehension and engagement. (Dougherty, 2021; Jonsson, 2017).

While both training models offer learning value, research suggests that translanguaging is especially empowering in its capacity to validate learner identity and promote more inclusive training practices (Lewis et al., 2012b; García and Leiva, 2014). Translanguaging not only supports comprehension but also acknowledges multilingualism as a strength rather than a challenge to overcome.

Regarding translanguaging's grounding in adult education theory, Dewey, a foundational thinker in adult learning, emphasized that educators have an ethical obligation to understand their students' cultural backgrounds and develop instruction that connects with their interests (Dewey, 1938). Dewey's focus emphasizes the need to draw on local community contexts as meaningful educational tools.

For workers in the energy and construction industries, these contexts would include their worksites as well as their local workforce. Mustonen and Strömmer (2022) argue that socio-constructivist learning concepts call for deeper recognition of the learner's experiences, including their diverse experiences and linguistic resources they might bring to the training site and the worksite. In their study of vocational education, the researchers used the prior knowledge and experience of migrant adult learners as points of leverage in order to improve learning outcomes.

Furthermore, translanguaging takes into account Vygotsky's sociocultural theory and the concept of the Zone of Proximal Development (ZPD). Translanguaging allows educators to create more beneficial scaffolding opportunities and help learners operate beyond their independent performance levels. In his study of Thai learners, Kampittayakul (2018) found that tutorial sessions conducted in a translanguaging context yielded results that demonstrated significant learner growth, which they interpreted as an indicator of expanding their participants' communication range within their ZPD.

Translanguaging acts as a more flexible and dynamic delivery mechanism for learners who speak and understand multiple languages (García and Wei, 2014) and provides learners the opportunity to use their native language as a valuable resource for developing greater learning and reflection rather than an obstacle (Kaiper-Marquez, 2023). Despite its growing prominence in theory, this perspective has yet to be widely adopted in adult education policies or instructional approaches, particularly in the energy and construction industries, which are just now beginning to look at delivery options that include using models other than direct translation.

Benefits of Training Using Translanguaging

As Williams (2002), as cited in Lewis et al. (2012b), explains, translanguaging involves "using one language in order to reinforce the other, in order to increase understanding and in order to augment the pupil's activity in both languages," (p. 40). Building on this, Baker (2011) emphasizes that translanguaging can also support deeper subject comprehension, particularly in foreign language instruction.

As a learning delivery strategy, translanguaging enables learners who may not be comfortable training in English to: (a) process technical content more effectively, (b) develop deeper insights into language context and meaning, (c) maintain bicultural identities, and (d) engage more fully with the learning (Sayer, 2013; Martínez, 2013; García, 2013).

In their study of adult refugees in Uganda, Marino and Dolan (2021) found that teachers who used translanguaging helped participants not only develop learning skills but also increase their feelings of empowerment. Beyond this, Gort and Sembiante (2014) found that translanguaging models created a responsive and inclusive classroom environment, which a) encouraged emergent bilingual students to participate more fully in academic discussions, (b) supported greater meaning-making, and (c) fostered students' active engagement.

McClain et al. (2021) found that using translanguaging style delivery methods in English-dominant preschools helped Spanish-speaking children participate more fully, allowing them to use Spanish alongside English to comprehend complex topics. This is particularly relevant to the construction and energy sectors, where safety language, hazard signs, training, and operating instructions are provided in English in accordance with the Occupational Safety and Health Administration (OSHA) compliance requirements.

Translanguaging for Safety

Recent workforce-focused studies show that translanguaging can also improve learners' engagement, comprehension, and perceived safety awareness (Gort and Sembiante, 2015; Mustonen and Strömmer, 2022; Wilkins et al., 2014). In workforce training contexts, where technical terms and safety-critical information must be absorbed and applied quickly, translanguaging strategies, provided they reinforce and comply with OSHA signage requirements, could offer a pathway to better learning outcomes and workforce readiness.

While there are few, if any, direct studies on translanguaging used directly in safety training or to increase safety awareness, the documented benefits of increased engagement, empowerment, and comprehension (García and Wei, 2014; Mustonen and Strömmer, 2024; Sulaiman and Taqi, 2020) suggest that incorporating translanguaging strategies could enhance safety training outcomes. By allowing learners to access and express information in their preferred languages, trainers can create more inclusive environments that facilitate better understanding and retention of safety protocols.

Translanguaging also supports greater equity and access in the energy industry contracting workforce by disrupting English-only paradigms that dominate traditional adult training programs. Research has shown that these English-only delivery models reinforce systemic inequities in education and labor markets (Auerbach, 1993; Flores and García, 2017). Integrating translanguaging into workforce safety training programs, particularly in workforces with diverse language standards, can help the delivery model become not just a tool to improve learning but an opportunity to help advance underserved communities and workers.

The research questions that this study was designed to answer include:

▶ How do NNES learners perceive the effectiveness of translanguaging strategies in safety training courses?

▶ Which translanguaging techniques (e.g., English keyword prompts, bilingual narration, glossary visuals) are perceived by NNES learners as most helpful for comprehension and engagement?

◢ METHODOLOGY

This study employed a quantitative, survey-based research design to examine the effectiveness of translanguaging techniques in industrial safety training courses for NNES adult learners. Specifically, this study used a descriptive, cross-sectional survey design to measure learner perceptions of training effectiveness across three safety courses that incorporated translanguaging as a delivery model. The research aims to evaluate comprehension, perceived effectiveness, and learner satisfaction of courses provided in this style within this learning community.

The study took place at a non-profit safety council in the Gulf Coast of the Southern United States, which has been training contractors in the energy and construction industries for decades. To protect confidentiality under our institutional review board (IRB)-approved protocol, all organizational and personal identifiers have been anonymized, and potentially identifying particulars such as precise location and program titles have been generalized.

Participants included adult learners enrolled in one of three Spanish-language safety courses intentionally designed with translanguaging strategies. The courses were three different safety orientation courses: (a) Group 1—a general safety training course with general worksite safety information and standards for contractors who perform and support work in the construction and energy industries, (b) Group 2 and Group 3—two safety training courses that included similar information to the course taken by participants in Group 1, but were designed specifically for two distinct client sites, each with their own unique worksite safety standards.

The safety council designed these courses to incorporate translanguaging pedagogy, allowing learners to draw from their linguistic repertoire to engage with instructional content (García and Wei, 2014). This approach differed significantly from traditional translation by integrating: (a) English "keyword" callouts alongside Spanish content, (b) side-by-side glossary items with bilingual labels, (c) bilingual narration and images, and (d) contextual visuals to reinforce terminology. This design supports the idea that language is not a barrier but a resource for meaning-making, consistent with established research in multilingual adult learning (Merriam and Bierema, 2013; Vogel and García, 2017).

The researchers and the safety council's eLearning development team developed all of the courses used for the study. The content was reviewed by industry subject matter experts (SMEs) and Certified Safety Professionals (CSPs) for correctness and adherence to OSHA standards.

Data collection procedures followed the already established safety council learner identification and test-taking policies, modeled off of the processes advocated by the Higher Learning Commission (HLC) (2022). Study participants, regardless of condition, took their courses at a non-profit safety council contractor training facility using one of the standard computer terminals used by that council for course delivery or through the safety council's proctored, online delivery system. Regardless of delivery method, a trained, safety council proctor was on hand to answer learners' questions and discourage cheating. The proctor was either able to speak Spanish or had immediate support from other proctors or managers who spoke Spanish.

This was done to ensure the NNES participants were supported if they had questions regarding: (a) the course in general, (b) course instructions, (c) the study's consent form, or (d) the study in general.

The participants were registered to take the courses by their employers within the safety council LMS using the safety council's established procedures. Training delivery integrity was ensured by the established and audited safety council learner verification process, which verifies learner identification against a valid picture ID and other biometric data located in the safety council LMS.

The safety council learner verification process includes three standard, progressive identification checks and spot checks by proctors throughout the learner's completion of any course. This process is audited annually by a third-party organization to ensure adherence to the following policies and procedures.

The three times the learner's identification is verified throughout the process of completing any safety council courses, including the ones used for this study, are: (a) at the registration desk when the learner enters the safety council lobby and receives a training ticket, (b) when the learner arrives at their workstation, and (c) when the learner completes their courses. Additionally, proctors spot-checked throughout the course delivery process to ensure that the learner who checked in and started the course was the same learner who completed the assigned course.

The study participant's picture was displayed for the safety council proctor to use as a point of comparison at every training station that the participant used during the course delivery, regardless of treatment.

The learner's picture is taken as a part of the safety council's learner verification process, at the time of the learner's initial registration. This picture is updated by safety council proctors after initial registration on an annual basis or as necessary by the safety council.

Study participants were given informed consent to be a part of this study by accepting a consent form at the beginning of the course delivery, regardless of which course they might have taken.

This was delivered at the time of course initiation via the safety council LMS. This consent was developed following principles outlined by Leavy (2017) to ensure that participants understood: (a) the voluntary nature of their participation, (b) the fact that all data would remain confidential, (c) that participants' names would remain anonymous, and (d) other information and details about the participants' rights.

Upon course completion, participants were presented with a six-question survey to assess their learning experience. Statements addressed: (a) clarity of course terminology, (b) helpfulness of English keywords, (c) knowledge gain related to safety, and (d) perceived ease of quiz items. This bilingual survey, developed by the council's instructional design team, was informed by adult learning theory and usability standards for digital learning (Merriam and Bierema, 2013). By evaluating these indicators, the researchers sought to identify correlations between translanguaging strategies and learner outcomes in multilingual training contexts (García, 2009).

All data were collected only after the study was approved by the IRB of Kansas State University to ensure that ethical standards for data collection were met. Quantitative data were analyzed using descriptive statistics to assess patterns across courses and learner subgroups. Data were anonymized, securely stored in compliance with institutional policies, and not linked to employer or learner records.

RESULTS

Between September 1, 2023, and November 30, 2023, 248 participants completed post-course surveys across the three safety courses that included translanguaging delivery methods. Across all courses, learners reported high levels of agreement, indicating positive perceptions of course clarity, engagement, and comprehension.

When looked at in aggregate, across all three courses, 73% of respondents agreed that the terminology in the course was easy to understand, 81% agreed that the English keywords throughout the course were helpful, and 89% felt more knowledgeable about safety after taking the course, as shown in Table 1. These findings reinforce that participants generally perceived translanguaging strategies as effective for supporting comprehension and safety knowledge.

QUESTION	AGREE		NEUTRAL		DISAGREE	
The terminology in the course was easy to understand	182	73%	42	17%	24	10%
The English keywords throughout the course were helpful	201	81%	25	10%	22	9%
I found the course easy to navigate	208	84%	19	8%	21	8%
I am comfortable taking computer-based courses	206	83%	22	9%	20	8%
I feel more knowledgeable about safety after taking this course	221	89%	6	2%	21	8%
The questions were easy for me to answer	175	71%	49	20%	24	10%

Table 1: Comparison of Learner Responses for Spanish-Language Safety Courses Using Translanguaging Strategies

Notably, the participants in Group 1, the course on general worksite safety, received the highest agreement across all dimensions, with 89% of learners reporting increased safety knowledge and 84% finding the course easy to navigate, as shown in Table 2. In contrast, Group 2 respondents, who took a class that was more specific to the worksite owner's policies and procedures, perceived terminology clarity (65%) and quiz question clarity (57%) less favorably, suggesting some translanguaging features were not viewed as equally helpful across all contexts.

QUESTION	GROUP 1		GROUP 2		GROUP 3	
The terminology in the course was easy to understand	138	73%	15	65%	29	78%
The English keywords throughout the course were helpful	152	81%	16	70%	33	89%
I found the course easy to navigate	157	84%	19	83%	32	86%
I am comfortable taking computer based courses	157	84%	16	70%	33	89%
I feel more knowledgeable about safety after taking this course	168	89%	18	78%	35	95%
The questions were easy for me to answer	133	71%	13	57%	29	78%

Table 2: Comparison of Learner Agreement Across Three Spanish-Language Safety Courses Using Translanguaging Strategies

Although test scores were not the primary focus of this study, course pass rates generally aligned with participants' perceptions. Group 1 participants, who rated clarity and helpfulness highly, achieved stronger course outcomes, while a smaller proportion of Group 2 participants passed, reflecting their less favorable perceptions of terminology and quiz items.

The survey data across the six different questions were analyzed to determine if there was any statistical significance, which could help determine if what the participants answered was valid or if the differences were due to chance. A chi-square test for homogeneity is a statistical test of independence designed to compare categorical data and evaluate differences in distribution across those groups. Our analysis included an evaluation of the overall data using a chi-square statistic, represented as χ^2, which measures the total deviation between observed and expected counts.

This overall evaluation revealed a statistically significant difference in the distribution of responses across these items, $\chi^2(10, N = 248) = 53.84, p < .001$, indicating variation in how learners perceived the helpfulness of different course components. Specifically, items related to safety knowledge and course navigation received higher agreement rates, while questions about terminology clarity and quiz difficulty showed more mixed responses. This suggests that some translanguaging techniques, such as keywords and narration, were viewed as more effective than others depending on the course context.

To further explore these differences, post-hoc chi-square tests were conducted to compare pairs of groups (G1 vs G2, G1 vs G3, G2 vs G3) on each survey item, with Bonferroni correction applied ($\alpha = .00278$).

These pairwise comparisons using post-hoc chi-square tests are done to determine whether any two groups differed significantly in their responses. A Bonferroni correction is applied because making multiple comparisons increases the chance of finding a difference by random chance, and the correction lowers that risk by using a stricter significance threshold. However, none of the pairwise comparisons reached statistical significance. While descriptive percentages suggested modest differences, these differences were not statistically distinguishable given the sample sizes.

These results provide evidence that participants' answers that differentiated techniques among translanguaging strategies were unique. Safety messaging and keyword use were perceived as especially helpful, while other elements, such as terminology and quiz items, were rated less so.

DISCUSSION

Across all three courses, participants reported high levels of agreement that the training improved their understanding and made them feel more knowledgeable about safety. This suggests that when learners are given opportunities to engage with course content through a combination of Spanish narration, bilingual visuals, glossary of terms, and English keywords, they are more likely to retain key concepts and feel confident applying them on the job. The strength of this response, particularly in Group 3, where 95% of participants reported increased safety knowledge, offers compelling evidence that translanguaging enhances comprehension and confidence, both of which are critical components of effective safety training.

Moreover, learner agreement on questions related to comfort with computer-based training (CBT) and ease of course navigation highlights an often-overlooked benefit of translanguaging: it not only supports cognitive understanding but also reduces learner anxiety and enhances accessibility. When technical training is delivered in a way that feels linguistically and culturally familiar, learners are more likely to engage fully and trust the training process. This aligns with adult learning theory, which emphasizes the importance of learner comfort, prior experience, and relevance in designing effective instructional experiences (Merriam and Bierema, 2013).

While direct translation alone may help learners pass compliance tests, translanguaging offers something more; it supports: (a) deeper learning, (b) better transfer to real-world application, and (c) an inclusive experience that respects learners' full identities. The statistically significant variation in learner agreement across survey questions reinforces the idea that instructional design matters. Not all content is received equally, and the data suggest that certain translating approaches and features are especially impactful when delivered through a translanguaging approach. These findings support prior research (Wilkins et al., 2014; Mustonen and Strömmer, 2024) suggesting that translanguaging strategies enhance both learner comprehension and perceived readiness, especially in safety-critical training environments.

This study has several limitations, including the fact that although the survey instrument was developed by instructional designers and reviewed by subject matter experts, no formal psychometric testing was conducted, which limits claims about validity and reliability. Additionally, the study employed a convenience sample of learners already enrolled in contractor safety courses at a Gulf Coast non-profit safety council, which may affect the generalizability of the results. Finally, the study relied on self-reported perceptions of learning effectiveness rather than objective performance measures. While these factors limit the scope of inference, they provide important direction for future research on translanguaging in workforce safety training.

Future studies around this research should examine whether these positive perceptions translate into measurable improvements in performance and retention outcomes, offering additional insights for workforce policy makers. Although no pairwise differences were statistically significant, the smaller sample size in Group 2 likely reduced power to detect modest between-group differences. Future studies with larger and more balanced group sizes could clarify whether site-specific courses produce different learner perceptions compared to general safety orientations. Additionally, this study did not assess participants' baseline Spanish literacy or fluency, as the focus was on perceived efficacy of translanguaging strategies within CBT courses. Future research may wish to incorporate such assessments to better understand how literacy levels interact with training outcomes. Finally, future studies might want to consider longitudinal data collection strategies to examine whether these positive perceptions persist over time and translate into measurable improvements in workplace safety performance.

CONCLUSION

As the construction and energy industries face growing linguistic diversity, ensuring that all workers, regardless of language background, can fully comprehend safety procedures and workforce training is not just a matter of inclusion, but of operational necessity. This study highlights how translanguaging, strategically using both English and Spanish during instruction, can enhance adult learner engagement, increase content comprehension, and ultimately support safer work environments.

Participants in this study reported improved confidence, clearer understanding of technical concepts, and greater comfort engaging with training materials when allowed to draw upon their full linguistic repertoire. These findings suggest that translanguaging may be especially valuable in high-risk sectors like construction and energy, where miscommunication can have serious consequences.

Although English remains the dominant language of safety training in the United States, this research demonstrates the practical benefits of bilingual and translanguaging strategies in workforce education. As more training programs begin to incorporate multilingual delivery, employers, educators, and policymakers should consider how to scale and formalize these approaches across industry settings. Doing so could lead to better learning outcomes, safer jobsites, and a more inclusive and effective workforce development system.

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Sustainability and Safety: A Prevention through Design (PtD) Success Story

BRUCE LYON
CSP, P.E., SMP, ARM, CHMM, FASSP - Bruce.Lyon@bbrown.com

DR. TSVETAN POPOV
CIH, CSP

DR. GEORGI POPOV
CSP, QEP, ARM, SMP, CMC, FASSP, FAIHA

⟋ ABSTRACT

Prevention through Design (PtD) addresses occupational safety and health (OSH) needs in the design and redesign phases to prevent or reduce the work-related risks to 'As Low As Reasonably Practicable' (ALARP). PtD concepts and methodologies have been successfully applied by various industries to specific projects involving different phases of a system's design, construction, installation, operation, maintenance, repair, and end-of-use for the purpose of avoiding and reducing OSH risks. In addition, PtD concepts can be applied to such projects for the purpose of improving productivity, efficiency, and sustainability.

EHS professionals face challenges in persuading management that safety and sustainability efforts can greatly benefit the organization in achieving business objectives. To be successful, EHS professionals must become change agents and help management transform safety and sustainability into an accepted business value for the organization. This requires EHS students and professionals to understand PtD principles and help integrate them into standard business and sustainability practices.

A major barrier to the adoption of PtD sustainability initiatives is the perception that the cost/benefit ratio of such projects is unfavorable. EHS professionals should recognize business cost drivers and justify PtD expenditures in the early stages of sustainability projects, green buildings, and product development. The authors have developed a PtD model that can help EHS professionals make the business case for PtD sustainability projects. The PtD model incorporates risk assessment, hierarchy of risk treatment (HoRT), productivity, sustainability, financial analysis, and future state projections. This model addresses the current Board of Certified Safety Professionals' (BCSP) Associate Safety Professional (ASP) and Certified Safety Professional (CSP) examination domain changes.

⟋ INTRODUCTION

The first PtD standard was published in 2011 with the primary goal to help educate designers; engineers; machinery and equipment manufacturers; environmental, health, and safety (EHS) professionals; business leaders; and workers in understanding and implementing PtD methods in the design and re-design of workplace facilities, processes, equipment, tools, methods, and even sustainability initiatives.

ASP (BCSP, 2025a):

Domain 1. Calculate financial indicators (e.g., cost-benefit analysis, cost of risk, life cycle cost, return on investment, effects of losses)

Domain 2. Apply appropriate hazard and risk analysis methods (e.g., hazard analysis, fishbone, change analysis)

Domain 3. Ergonomics

Domain 7. Environmental management

CSP (BCSP, 2025b):

Domain 1. Describe the principles of minimizing hazards using Prevention-Through-Design

Domain 2. Describe the Management of Change process (prior, during, after);

Recognize safety, health, and environmental management and audit systems (e.g., ISO 14000 series, 45001, 19011, ANSI Z10);

Describe system safety analysis techniques (Safety Case approach, risk summation)

Apply budgeting, finance, and economic analysis techniques and principles (e.g., timelines, budget development, resourcing, return on investment, cost/benefit analysis, role in procurement process)

Domain 3. Risk Management

Domain 5. Environmental Management

To demonstrate the applicability of the model and provide practical examples of BCSP's ASP/CSP domains application, the authors would like to present a case study that was suitable for practical demonstration and for use as a best practice model. A sustainability project for refuse truck improvements will be discussed in this paper. In the model, PtD principles were combined with recently developed risk assessment tools, productivity improvements, and environmental and sustainability initiatives. This case study demonstrates how EHS professionals can play a significant role in the development of new sustainability projects, business plans, and the implementation of Lean Six Sigma (LSS) practices, designed to reduce the risk of injuries and illnesses and improve productivity.

Research Question

This paper focuses on developing a new decision-making model to study whether PtD methods are applicable in environmental, safety, and sustainability improvement projects.

History of PtD

Prevention through Design is not a new concept and, as with many worthwhile endeavors, has roots in the work of several previous individuals and organizations (Manuele, 2007; ANSI/ASSP, 2021). The work of Edward Deming via his total quality management (TQM) process certainly provided foundational underpinnings for PtD (Manuele, 2008; Deming, 1982). Deming gives credit to others for the TQM process, and thus the circle continues to turn and involve many participants. The American Society of Safety Professionals (ASSP) published a position paper on Designing for Safety in the 1990s (ASSE, 1994).

The National Institute for Occupational Safety and Health (NIOSH) gave the PtD movement a boost via a variety of meetings and publications, starting in the 1990s. In late 2010, NIOSH released its PtD plan (NIOSH, 2010). ASSP and the American Industrial Hygiene Association (AIHA) have also provided significant support for PtD. ASSP is the Secretariat for the first version of the standard and the updated ANSI/ASSP version of the PtD standard.

PtD has been gaining momentum for the past several years, as evidenced by its inclusion in current occupational safety and health textbooks (Blunt, et al., 2011; Lyon and Popov, 2020). The authors believe this trend will continue for the foreseeable future, as Fred Manuele's publications indicate (Manuele, 2008a; Manuele, 2008b).

Research Project Description

Trash collection requires a significant number of repetitive manual material handling movements by workers, resulting in musculoskeletal disorders (MSDs), including lower back and carpal tunnel syndrome (CTS) injuries. For the organization in the study, the additive effect of these safety risks was recognized as a main concern for its business continuity and sustainability goals. Human Resources (HR) reported difficulties in hiring new employees, and the organization experienced a high turnover rate. As a result, management needed to take steps to reduce MSDs risks and improve productivity.

This research project demonstrates potential savings an organization can realize from the implementation of PtD and sustainability initiatives. The organization formed a risk reduction team to help prepare a business case for improvement.

The team identified priorities and developed a project model. The purchase of new mechanized refuse trucks had to be justified. PtD and sustainability goals were identified as a key component of the project. The main requirement was that the new refuse trucks were to be designed in a way to eliminate or significantly reduce MSDs risks.

The recommendation was to utilize PtD, risk management, and LSS tools to perform a current state-of-the-art risk assessment and develop intervention priorities. PtD and risk reduction tools were utilized to develop future-state risk estimations and projections. Productivity gains were evaluated utilizing common LEAN tools, and project cycle efficiency (PCE) was calculated for current state productivity and future state projections. A modified fishbone diagram was then used to evaluate the current state vs. the future state process.

To analyze and evaluate potential solutions for this project, the authors developed a Microsoft Excel-based business analysis tool. The tool was used to evaluate a number of business-related factors, including total annual incidence cost before the intervention and total annual incidence cost after the intervention, and to calculate incident benefit and cost savings. The team performed an estimated return on investment (ROI) by adding net savings, new revenue (generated from increased productivity), and other savings on maintenance, fuel, insurance, etc. The estimated ROI was displayed as a numerical value as well as a percentage. The team also estimated the net present value (NPV) and the payback period for the safety investment. Note: Internal rate of return (IRR) is another business term and is usually considered a simplified alternative to NPV. The tool calculates and displays IRR as a percentage.

Recognizing that business managers prefer to see comparisons of several proposals rather than a single solution, a worksheet was developed and presented to compare four different proposals. The NPVs for the different proposals were compared and displayed as numerical values, while IRR and ROI for all proposals/solutions were displayed as percentages. To satisfy expectations and gain support for EHS improvements, the team conducted a cost-benefit analysis to assess potential risk reductions. Based on the initial analysis, it was decided to move forward with new mechanized compressed natural gas (CNG) refuse trucks.

The business analysis revealed a payback period of a little more than four years with an IRR of 12%. The organization's management requested that non-financial benefits be included in the model for a comprehensive evaluation. The organization requested assistance from an EHS consulting team to evaluate the emissions of its existing diesel trucks and compare them to those of the new CNG trucks from a sustainability perspective. Particulate matter (PM 10), NO2, and CO levels were evaluated. In addition, volatile organic compound (VOC) levels were also compared. The air was tested for VOCs utilizing a photoionization detector (PID). The sampling was performed utilizing a PID with an ionization potential (IP) for the UV lamp of 10.6 eV. The air quality pollutants were measured near the side platform (step) where the refuse collector steps on and holds onto the handle. These measurements were considered as air quality screening only.

Considering the projected safety improvements (reduction of MSDs exposures), gains in productivity and non-financial benefits, and reduced air pollutant emissions, management made the decision to invest in the new CNG truck fleet.

/ METHODOLOGY

A new PtD and business analysis decision-making model was used to evaluate improvements to the refuse collection process. This research identified potential areas for EHS professionals to consider the business aspect in the evaluation and decision-making process. The new PtD model developed by the authors incorporates risk assessment, HoRT, productivity, financial analysis, and future state projections. The model follows Define, Measure, Analyze, Improve, and Control (DMAIC) logic. Separate tools were developed for each phase. For instance, Delphi, brainstorming, and preliminary risk assessment (PRA) were used in the "Define" phase. A semi-quantitative risk assessment matrix (RAM) was used in the "Measure" phase to prioritize the risks and modify the procedure to estimate risk reduction after the proposed EHS intervention. A striped bowtie risk assessment method was used to estimate total risk or risk summation (CSP 11, Domain 2). Several other tools were utilized during this evaluation, including value stream mapping (VSM), PCE, and the Pareto 80/20 analysis. Next, adjustments were made, and the improvements were evaluated utilizing Lean Six Sigma tools.

Air pollutant levels were evaluated for the current diesel trucks and compared to the new CNG trucks. The emissions were evaluated utilizing direct reading instruments.

The authors present the following case study to demonstrate the applicability of the newly developed PtD and sustainability model. For confidentiality purposes, the team members and company name have been removed

Case Study

Refuse collection companies that still operate manual trash collection services typically have a very high MSD rate. This can lead to a high turnover rate, a high absenteeism rate, and significant financial losses for the company. Therefore, a risk-based business plan for replacing old refuse trucks with new mechanized trucks was needed.

To begin, an ergonomics risk assessment was completed utilizing the PtD risk assessment tools. High-priority areas for improvements were identified and evaluated. The study included an initial cost-benefit analysis, and gross cost savings from EHS interventions were calculated. NPV, payback period, simple ROI, and IRR calculations from EHS interventions were also included in the study.

The main purpose of the project was to demonstrate the benefits of mechanized refuse collection trucks compared to conventional refuse collection trucks currently in use (Exhibit 1).

EXHIBIT 1

Refuse Collection Trucks

Conventional refuse collection trucks

Mechanized refuse collection trucks

Simple digital images were used to understand the process and develop a possible intervention plan. However, the authors had to develop a comprehensive management plan that would lead to a complete analysis of the process and convince the management of the benefits of investing in new trucks. The team members observed the process and recorded the time required for each step. The steps are presented on the next page:

STEP 1.

Position the refuse truck.

STEP 2.

Lift two polyethylene bags.

STEP 3.

Lift and dump the bags.

STEP 4.

Repeat steps 2 and 3, lifting and dumping two more bags. Four polyethylene (poly) bags are allowed per household.

STEP 5.

Compress/compact the trash.

STEP 6.

Refuse collector steps on the side platform (step) and holds on to the handle.

STEP 7.

Drive to the next house.

An initial risk assessment was performed to assess and estimate the safety risks and the potential injuries. After several meetings with the company's risk management and accounting professionals, the team developed a worksheet with risk estimation options. Risk was estimated based on a 5x5 risk assessment matrix (RAM), presented in Fig. 1. The formula selected to estimate risk level was a simple multiplication of Severity x Likelihood, resulting in a risk level between 1 and 25. The risk results were color-coded for better visualization.

FIGURE 1

5x5 Risk Assessment Matrix

FIGURE 1 — 5x5 Risk Assessment Matrix

	Incident Outcomes			Likelihood of Occurrence				
Severity Rating	Health Effects (People)	Property Damage	Environment Impact	1 Very Unlikely	2 Unlikely	3 Possible	4 Likely	5 Very Likely
5	Death or permanent total disability	Catastrophic damage	Significant impact	5	10	15	20	25
4	Permanent partial disability; hospitalizations of three people or more	Severe damage	Significant, but reversible impact	4	8	12	16	20
3	Injury or occupational illness resulting in one or more days away from work	Significant damage	Moderate reversible impact	3	6	9	12	15
2	Injury or occupational illness not resulting in a lost work day	Moderate damage	Minimal impact	2	4	6	8	10
1	First aid only or no injuries or illnesses	Light damage	No impact	1	2	3	4	5
	Very high risk: 15 or greater High risk: 10 − 14 Moderate risk: 5 − 9 Low risk: 1-4							

Next, the preliminary risk assessment worksheet was completed to individually assess the risks. The risk assessment worksheet used was based on the well-established risk pathway model (ASSP TR 2020) and is presented in Fig. 2.

FIGURE 2
Current State Risk Assessment Worksheet

The PRA method shown in Fig. 2 is a linear method that was used to individually assess each risk. The PRA model is commonly used for risk prioritization. Based on the presented current state risk assessment, it was clear that back strain exposure was the highest risk for this operation. Note that to consider the additive effects of the individual risks, the risk summation method, as stated in BCSP's CSP Domain 2, was used to assess the total risk level. For example, heat stress can increase the risk of MSDs for workers performing repetitive manual material handling, like refuse collectors. The additive effects of physical exertion in hot conditions can lead to fatigue, decreased dexterity, and impaired judgment, increasing the risk of injuries such as strains, sprains, and other MSDs (NIOSH, 2024). In addition, the severity of the additive effects of such exposures may lead to hospitalizations or even fatal outcomes.

To address some of the shortcomings of the linear risk assessment model, the authors developed the striped bowtie model (Lyon and Popov, 2017), as depicted in Fig. 3.

FIGURE 3
Striped Bowtie Model for Refuse Collectors' Risks
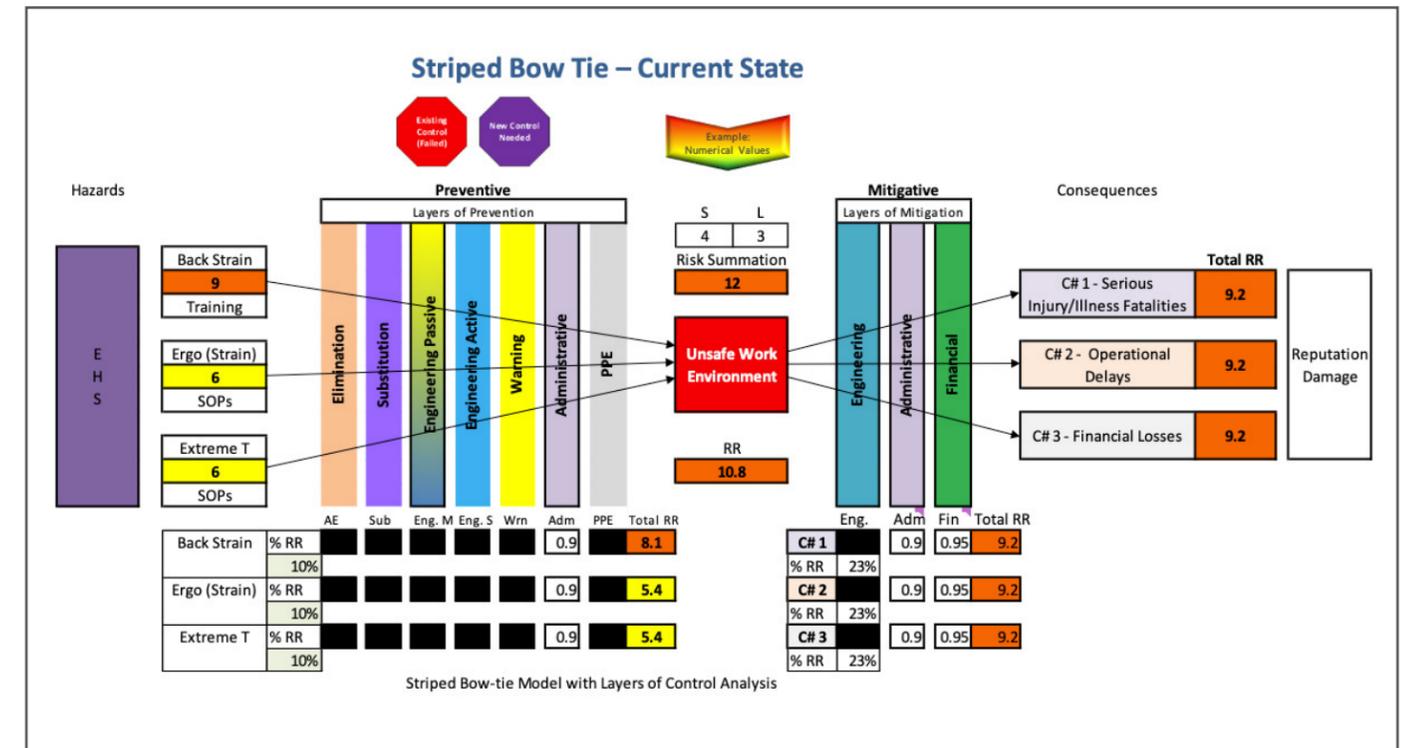
The total risk or risk summation level, as shown in Fig. 3, was estimated at 12, compared to individual risks of 9, 6, and 6, respectively. This risk summation estimation is based on the fact that the additive effects of extreme temperatures may likely increase the risk of MSDs. Also, the total risk was reduced by only 10% because the only preventive measures in place were administrative controls.

A Pareto chart was prepared to visualize the highest cost of injuries and illnesses. Not surprisingly, MSDs were at the top of the chart for safety-related costs of injuries and illnesses. The financial expenses were clearly communicated to the risk manager, and it became obvious that the costs of injuries and illnesses were unsustainable. The next task was to collect data and prepare a cost-benefit analysis, as shown in Fig. 4.

FIGURE 4
Cost-Benefit Analysis Worksheet

The worksheet was developed specifically for this project; however, the format can be used for other projects. The form is an analysis of different categories and the financial impact of each category. Some categories were easily quantifiable, such as workers' compensation cost, annual salaries and benefits obtained from the accounting department, and fuel and maintenance costs obtained from the maintenance department. Unfortunately, the company's experience modification rating (EMR) for worker compensation claims was not shared with the team. EMR is the objective measurement of each employer's claims experience. The published manual rate for each state is multiplied by the employer's EMR to determine the premium rate paid by the employer. An EMR below 1.00 indicates that the employer will pay premiums below the manual rate. The organization was approaching an EMR of 1.00, and it was vitally important to lower the rate to avoid increased insurance premiums. Due to confidentiality concerns, the impact of EMR was not disclosed and could not be included in the calculations. The organization did not disclose the cost of hiring new employees. Therefore, it was not included in the calculations.

EHS professionals are well aware that obtaining all financial variables is not an easy task. Therefore, many what-if scenarios have to be prepared, and such scenario analyses are not uncommon. One scenario involved purchasing 10 brand-new automated waste collection trucks at $365,000 each. In this short article, not all the details can be discussed; however, it is easy to understand how many variables are included in the financial calculations. The new trucks included a warranty and free maintenance for a year. After that, spare parts and maintenance costs had to be factored in.

The financial analysis shows that the project is not beneficial after the first year. Therefore, a more detailed financial analysis was requested. Simple three- and five-year NPVs were calculated, as shown in Fig. 5.

FIGURE 5
NPV Calculations

FIGURE 6
Payback Period Calculations

The analysis clearly shows that the NPV is negative after three years, but some benefits could be expected after five years. Therefore, the payback period (PbP) had to be calculated precisely, as shown in Fig. 6.

The reader will notice that this is a straightforward PbP calculation, excluding potential inflation calculations, spare parts, and maintenance costs after the first year. Therefore, the company requested a complete financial analysis. Following two meetings with various levels of company management, a worksheet was developed to estimate the project's economic benefits. Typical business tools and statistics were used to create the worksheet shown in Fig. 7. Notice that there are slight differences in values. The worksheet in Fig. 7 includes spare parts, maintenance costs, and 7% interest rate costs.

FIGURE 7
Financial Analysis
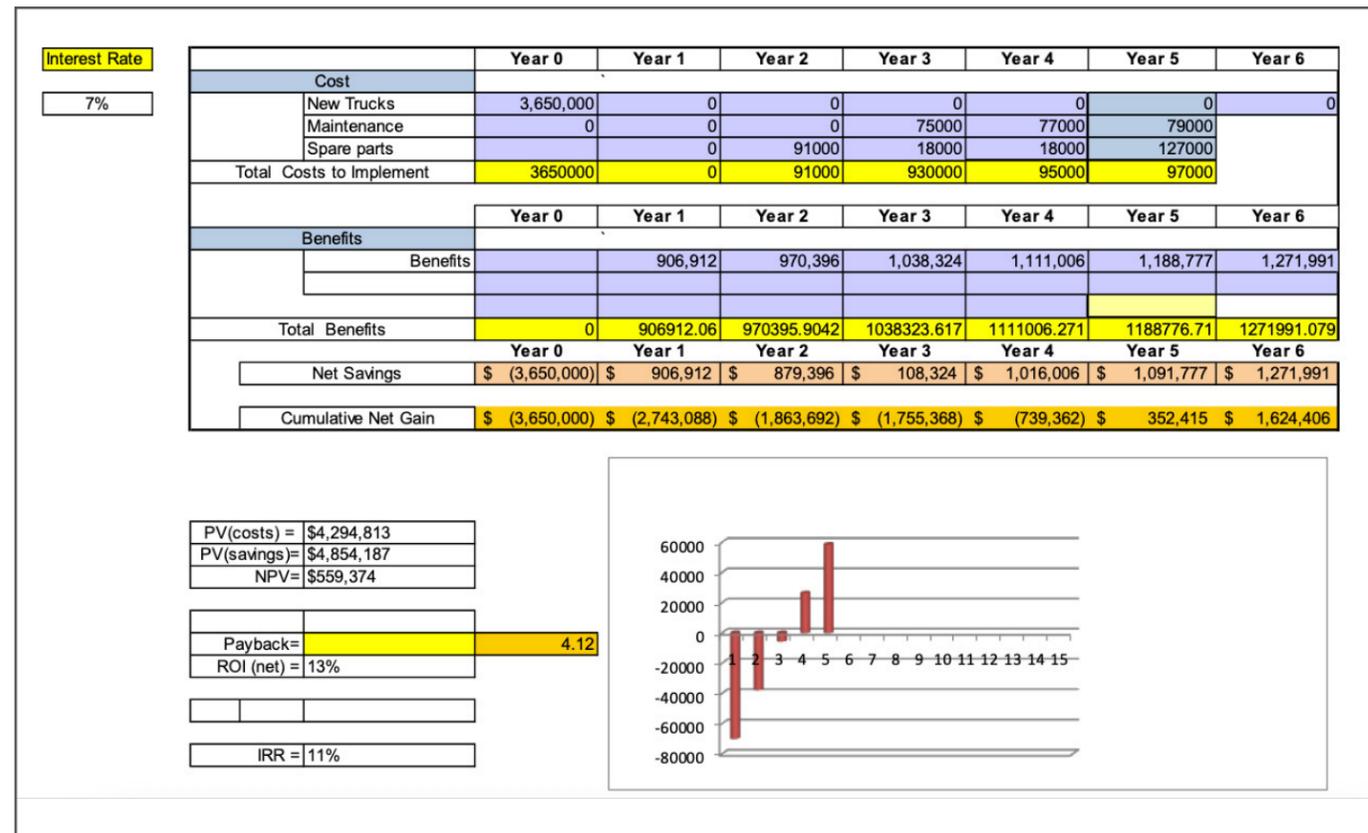
An interest rate of 7% was requested by the company. This was not a realistic interest rate at the time of the assessment. However, conservative estimates were required for this project. The worksheet and the built-in formulas allow for interest rate adjustments. The worksheet also includes IRR calculations. The IRR is a rate of return used in capital budgeting to measure and compare the profitability of investments. The IRR is calculated at 11%. For some companies, an IRR below 12% is not acceptable.

The payback period of 4.1 years was still unacceptable for the business managers. To capture other benefits and convince management, a new Lean Six Sigma tool was developed to measure productivity efficiencies. The current state PCE was evaluated and compared to the future state PCE. A combination of Six Sigma "suppliers, inputs, process, outputs, customers" (SIPOC) and Lean value stream mapping tools were utilized to present the benefits of the project (Fig. 8).

Notice the payback period. Organizations, financial professionals, and corporations commonly use the payback period to calculate investment returns. The upfront costs and the payback period became complex topics for discussion. Therefore, the EHS team used LSS tools to demonstrate productivity improvements to convince upper-level management that such an investment is justifiable from an economic, safety, and sustainability standpoint.

SIPOC and PCE were used. SIPOC diagrams are visual tools that map out a business process. PCE is a key metric in Lean Manufacturing that measures the percentage of time spent on value-added activities within a process. It is a simple formula, as shown in Eq. 1, and is calculated by dividing the value-added time (VAT) by the total lead time (TLT) it takes to complete the process.

PCE calculation:

$$PCE = \frac{VAT}{TLT} \quad (1)$$

FIGURE 8
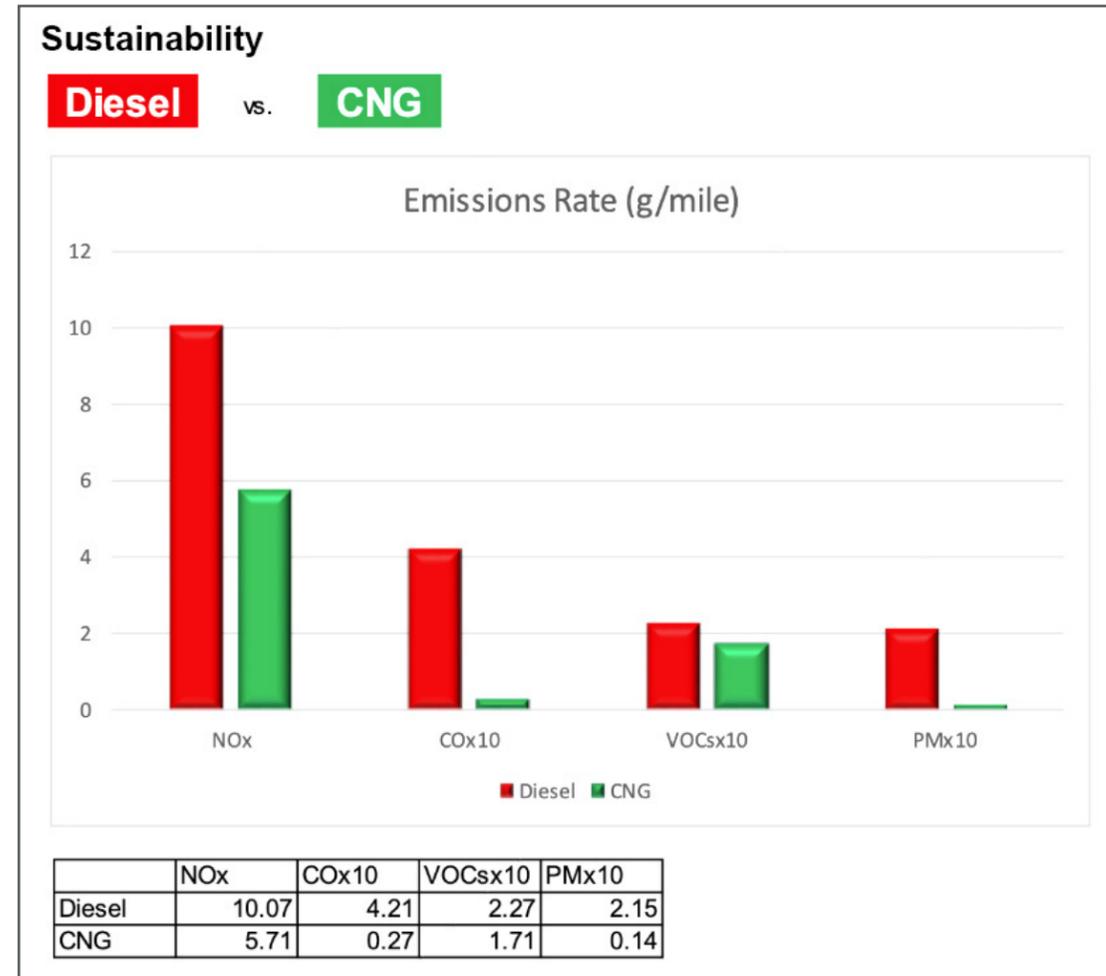*Current State SIPOC and PCE*
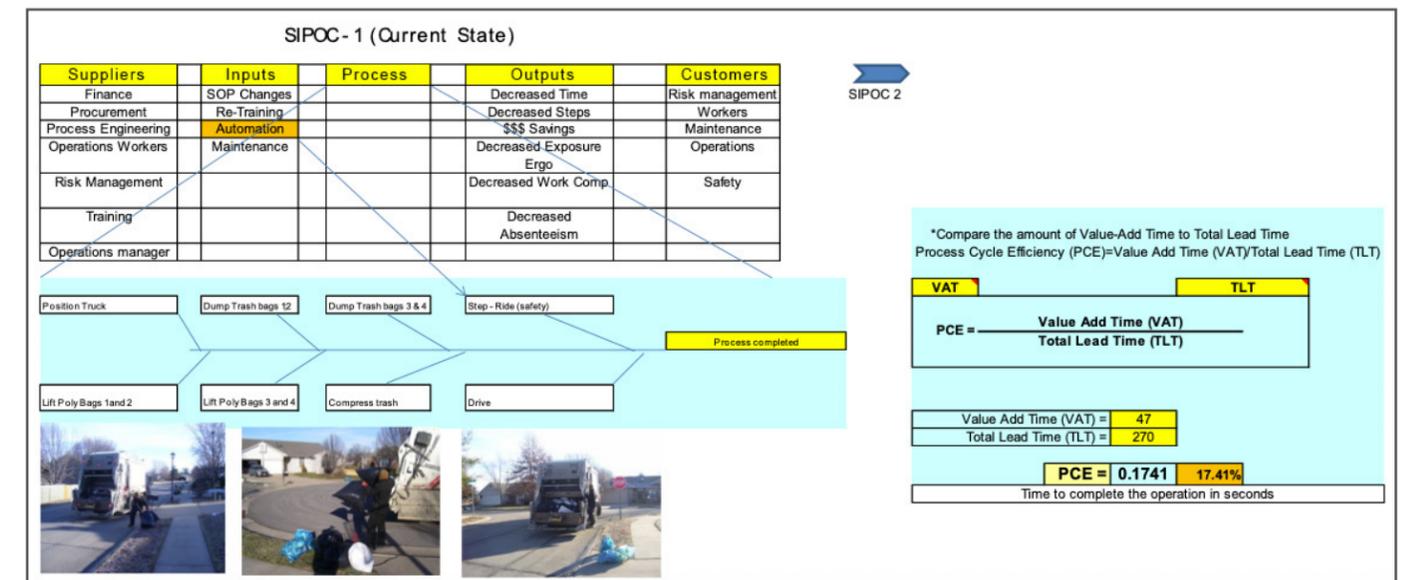
A modified fishbone diagram was used to present VSM because it is easy to use, understand, and visualize.

In addition, it was noticed that the project may have non-financial benefits as well. A concern existed for emissions from the refuse trucks. Therefore, the EHS team measured the emissions from the diesel refuse trucks. Another company that already implemented automated CNG trucks was kind enough to allow the authors to sample the CNG emissions for comparison purposes. Diesel emissions were higher in all categories for the older type of trucks measured. Substantial emissions reduction played a significant role in the decision-making process. Figure 9 provides the airborne data and comparisons for both types of trucks.

Switching to CNG presents opportunities from a sustainability perspective. Technically, CNG and renewable natural gas (RNG) are almost identical. CNG vehicles can run on RNG without any modifications. However, CNG and RNG differ in their origin. CNG is extracted from fossil resources, while RNG is obtained from organic waste such as landfills, sewage sludge, or animal manure.

As presented in this case study, switching to RNG is a way for waste management organizations operating fleets of vehicles to reduce their carbon footprint. Further risk assessment is needed; however, if fueling a refuse truck entirely on RNG is not practical, then blending with fossil CNG is possible. Even if a small percentage of RNG is used, it will result in an instant reduction in CO2 emissions without the need to invest in any upgrades or modifications to the refuse vehicle fleet.

Sustainability and reducing COx, NOx, VOCs, and PM emissions can play significant roles in decision making.

Instead of allowing landfill gas (LFG) to escape into the air, it can be captured, converted, and used as a renewable energy resource. According to the US Environmental Protection Agency (EPA), using LFG helps reduce odors and other hazards associated with LFG emissions and prevents methane from migrating into the atmosphere and contributing to local smog and global climate change. From a business perspective, LFG capturing generates revenue and creates jobs in the community and beyond. The process is illustrated in Fig. 10.
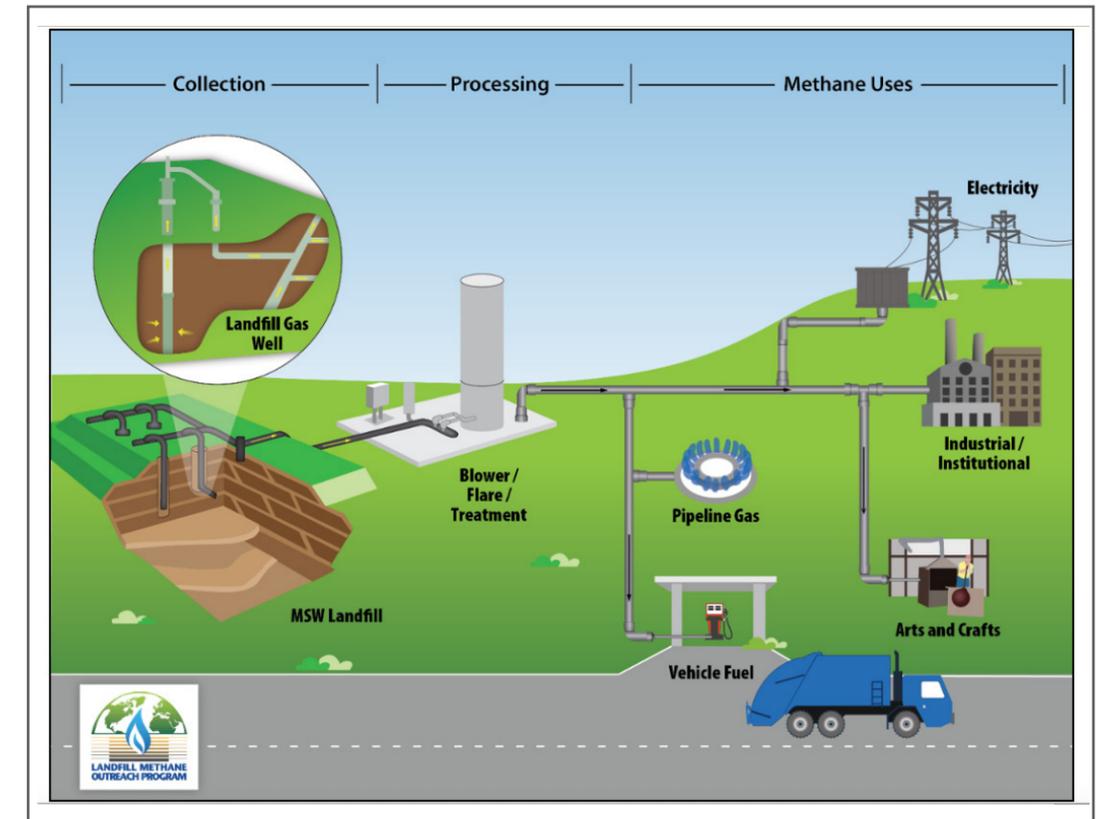
FIGURE 9
Air pollution – Sustainability

FIGURE 10
Collection and Processing of LFG to Produce Methane for Refuse Trucks and Other Uses

*Source:* https://www.epa.gov/lmop/basic-information-about-landfill-gas

/ RESULTS

Process improvements were evaluated utilizing Lean Six Sigma tools and modified risk assessment methodologies. The same SIPOC and PCE worksheet was used to assess future state improvements and process efficiency.

Future state SIPOC and PCE worksheets are presented in Fig. 11.

FIGURE 11
Future State SIPOC
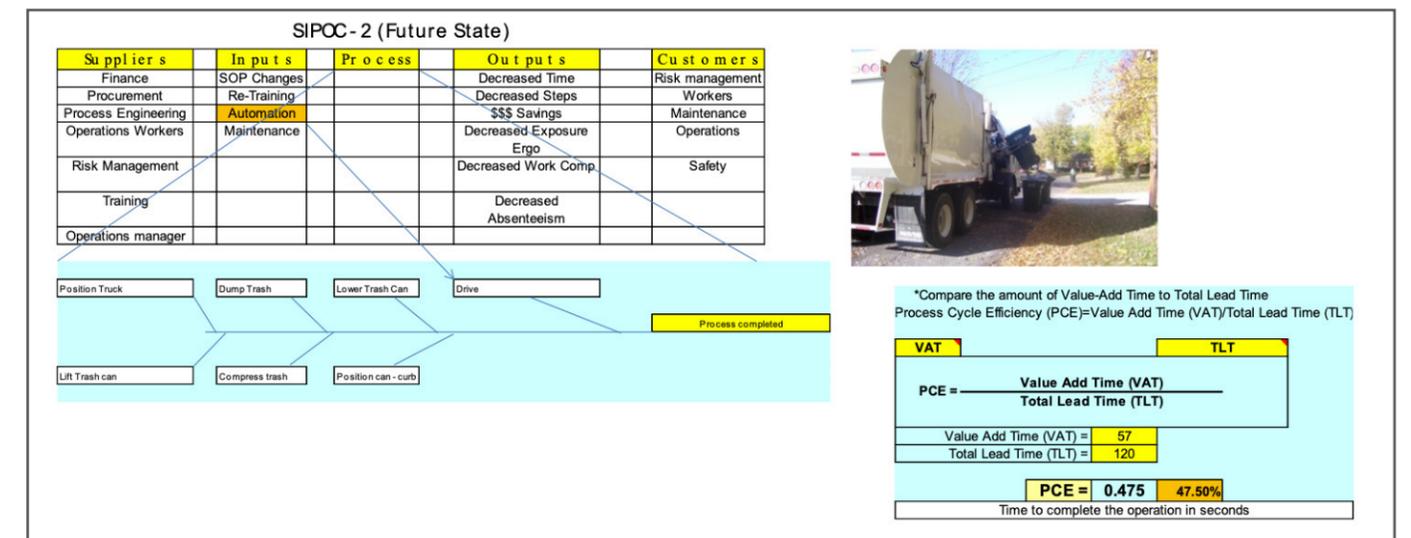
To assess and estimate risk reductions from the proposed plan, the team used PtD and risk assessment processes, which indicated significant decreases in MSDs, extreme temperature exposures, and the likelihood of fall hazards.

Due to implementing Lean practices, PCE improved from 17.41% to 47.50%. Possible EHS involvement in the process was evaluated. Based on the comparison calculations, PCE increased from 17.41% to 47.5%.

Significant reductions in EHS risks and increased sustainability/EHS improvements were also projected. As presented in Fig. 12, striped bowtie analysis for the future state visualizes risk reduction, which can help communicate risk to management and other stakeholders.

FIGURE 12
Future State Striped Bowtie Analysis
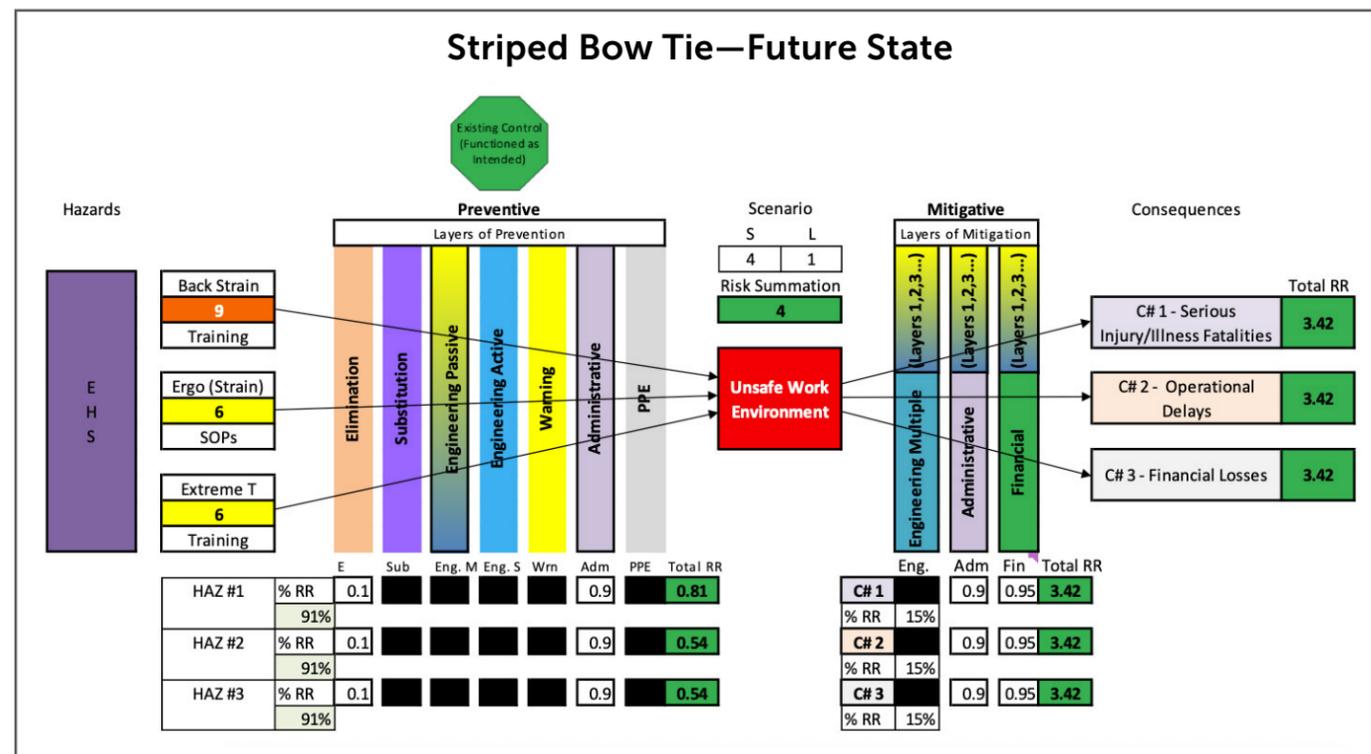
As shown in the striped bowtie risk assessment, the proposed EHS intervention was estimated to reduce high and moderate risk ratings to more acceptable low risk levels for employee injuries, operational delays, and overall financial losses.

The financial analysis estimated the PbP of 4.1 years and NPV as negative after 3 years, which were less-than-ideal results. Therefore, a more compelling argument was to communicate the importance of occupational risk reduction and sustainability opportunities. As a result, emissions reductions and sustainability played a significant part in the decision-making process.

Lessons Learned

To be successful, EHS professionals should develop management skills and diversify their knowledge to overcome difficulties during such projects. Significant investment projects, such as the case study presented here, are sometimes difficult to justify based on occupational risk assessment alone. Future leaders in the safety profession will have to develop risk assessment skills and demonstrate knowledge in financial management. In order to defend such projects, EHS professionals have to be familiar with a variety of risk management techniques, sustainability initiatives, LSS tools, and financial management principles. Being an expert in ergonomics is not enough to successfully complete complex projects. Complex projects require multi-disciplinary knowledge and cross-disciplinary management skills. Safety leaders have to become familiar with different organizational structures and the variety of stakeholders' interests to complete such projects. EHS professionals have to be prepared to deal with various levels of organizational management and demonstrate the value of sustainable projects.

CONCLUSIONS

EHS professionals can and should play a significant role in developing new business plans and sustainability initiatives that incorporate PtD, as well as implementing Lean Six Sigma practices designed to minimize injuries, improve productivity, and reduce wasted time. The PCE for this particular case study was improved significantly. The refuse collection process was made safer due to input from the EHS professionals. The project led to a decision by management to purchase new, safer, and sustainable refuse trucks, which presents opportunities to reduce injuries, reduce emissions, and improve productivity. BCSP's new ASP/CSP blueprints present great opportunities for EHS students and early-career professionals to improve their knowledge and skills.

It was concluded that sustainability could significantly affect occupational, operational, financial, and strategic risk management decisions.

To answer the research question, the presented case study demonstrates that PtD methods can be successfully applied in environmental, safety, and sustainability improvement projects.

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