Journal of Safety Research 78 (2021) 303–313

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

Making safety training stickier: A richer model of safety training engagement and transfer

Tristan Casey [a,*], Nick Turner [b], Xiaowen Hu [c], Kym Bancroft [d]

[a] Safety Science Innovation Lab, Griffith University, Brisbane, Qld, Australia
[b] Haskayne School of Business, University of Calgary, Calgary, AB, Canada
[c] QUT Business School, Queensland University of Technology, Brisbane, Qld, Australia
[d] Serco Asia Pacific, Brisbane, Qld, Australia

ARTICLE INFO

Article history:
Received 5 February 2021
Received in revised form 23 March 2021
Accepted 4 June 2021
Available online 25 June 2021

Keywords:
Learning and development
Safety training evaluation
Safety refresher training
Training relapse prevention

ABSTRACT

Introduction: Compared to other types of occupational training, safety training suffers from several unique challenges that potentially impair the engagement of learners and their subsequent application or "transfer" of knowledge and skills upon returning to the job. However, existing research on safety training tends to focus on specific factors in isolation, such as design features and social support. The aim of this research is to develop an overarching theoretical framework that integrates factors contributing to training engagement and transfer. *Method:* We conducted a comprehensive qualitative review of safety training research that was published between 2010 and 2020. We searched Web of Science, Scopus, and Google Scholar, yielding 147 articles, and 38 were included. We content analyzed article summaries to arrive at core themes and combined them with contemporary models of general occupational training to develop a rich model of safety training engagement and transfer. *Results:* We propose that training engagement is a combination of pre-training factors such as individual, organizational, and contextual factors, that interact with design and delivery factors. Safety training engagement is conceptualized as a three-component psychological state: affective, cognitive, and behavioral. Organizations should prioritize pre-training readiness modules to address existing attitudes and beliefs, optimize the safety training transfer climate, and critically reflect on their strategy to design and deliver safety training so that engagement is maximized. *Conclusions:* There are practical factors that organizations can use before training (e.g., tailoring training to employees' characteristics), during training (e.g., ensuring trainer credibility and use of adult learning principles), and after training (e.g., integrating learned concepts into systems). *Practical Applications:* For safety training to 'stick,' workers should be affectively, cognitively, and behaviorally engaged in learning, which will result in new knowledge and skills, improvements in attitudes, and new safety behaviors in the workplace. To enable engagement, practitioners must apply adult learning principles, make the training relevant, and tailor the training to the job and individual needs. After training, ensure concepts are embedded and aligned with existing systems and routines to promote transfer.

1. Introduction

Safety training is a core component of modern safety management. The goal of safety training is to provide workers with safety knowledge and motivation, encourage them to perform safety-relevant behaviors more often and more effectively, and ultimately contribute to a reduced risk of injury through safety behaviors (Burke et al., 2006; Griffin & Neal, 2000). From a contemporary safety science perspective, safety training also helps to improve organizational resilience (i.e., the ability of a system to succeed under varying conditions; Hollnagel, 2011) by equipping workers with improved capabilities to anticipate, respond, learn, and monitor. For instance, Malakis, Kontogiannis, and Kirwan (2010) investigated the role of safety training in air traffic control and showed that equipping operators with cognitive strategies contributes to overall system resilience. However, when safety training is poorly designed and executed, the consequences can go beyond the loss of financial and human resource investment; lives can be lost, errors made, and productivity reduced when safety training fails to transfer from the learning environment back to the workplace (Burke et al., 2006).

* Corresponding author.
E-mail address: tristan.casey@griffith.edu.au (T. Casey).

https://doi.org/10.1016/j.jsr.2021.06.004
0022-4375/

According to Krauss, Casey, and Chen (2014), safety training possesses unique challenges that are different from other types of occupational training. First, safety behaviors tend to be highly routinized and regulated, thus highly resistant to change. Safety training programs are often mandated by regulators and clients/-customers, meaning that there is a reduced sense of choice and self-determinism for the organization as well as the attendees. The motivation to engage with the safety training and its subsequent transfer might be further hindered by the bureaucratization of safety training (Dekker, 2019; Smith, 2018), where multiple and sometimes redundant or irrelevant training programs are mandated to employees. Finally, some of the knowledge and skills taught during safety training may only be used in emergency settings, increasing decay over time as there are limited opportunities to apply the knowledge. Transfer of emergency training is critical to safeguard life and minimize damage to infrastructure and assets. It has recently been studied in the context of immersive virtual reality technologies, which appear to increase learning of new skills and stimulate behavioral change and transfer (Feng et al., 2018; Wang et al., 2014).

Nevertheless, empirical evidence also indicates that when pre-training factors, features of training design and delivery, contextual factors, and post-training factors are considered, safety training can successfully reduce injuries and incidents at work, as well as promote better safety performance (Brahm & Singer, 2013; Robson et al., 2012). However, prior studies tend to focus on a narrow set of factors, such as social support (Freitas et al., 2017, 2019), personality, and motivation (Lingappa et al., 2020). Currently, there is no model that integrates multiple contributing factors and their impact on the safety training process, and that would help to develop a holistic and nuanced understanding of how training engagement and transfer could be facilitated (Krauss et al., 2014). Although the wider occupational training literature has generated integrative models (e.g., Ford, Baldwin, & Prasad, 2018; Sitzmann & Weinhardt, 2018), given the unique characteristics of safety training, the direct application of these models to safety might be inappropriate (Krauss, 2005; Krauss et al., 2014). For instance, in a safety training context, learners may hold attitudes toward safety or possess a safety "locus of control," there may be limited opportunity to apply learnings (e.g., for emergency scenarios), or safety training can be either mandated or voluntary, which might affect learner engagement.

In this paper, we synthesize these two separate lines of research to develop an integrative model for safety scientists and practitioners, present key theoretical insights, and identify practical opportunities to improve safety training engagement and transfer. We focus on onsite safety training that is delivered as standalone sessions, rather than a sub-section within broader occupational training. Our model draws on two key concepts that are relevant for training effectiveness—training engagement and training transfer—which describe the trainee's engagement with the training during its delivery and the subsequent application and generalization of skills and knowledge in their work setting, respectively. We draw on the latest training models from the occupational training literature, which highlight the importance of understanding training from a chronological and multilevel perspective and focus on both training design and delivery factors that create learner engagement, and, importantly, are within organizations' and trainers' reach to influence. With this theoretical backbone, we then enrich our model by incorporating empirical research in safety training from the past decade. In doing so, we respond to recent calls for more "consumer-centric" research that enables practitioners to design, deliver, and measure more effective training activities (Baldwin, Ford & Blume, 2017).

We start by providing a high-level overview of our proposed model and then discuss each of its components in detail. In the discussion, we focus on recommendations to improve safety training effectiveness through pre-training communication, using more engaging and impactful learning strategies, and integrating safety training into organizational systems and processes to provide insights to learners about when and how to apply their safety training.

2. Model development

To develop an integrative model (see Fig. 1), we first identified two key concepts that produce overall training effectiveness: training engagement and training transfer. Training engagement is a relatively understudied construct and either not explicitly defined by scholars (e.g., Sitzmann & Weinhardt, 2018) or defined implicitly through measurement proxies, such as number of levels or content accessed as part of a training program (Harvey, Balzer, & Kotwicki, 2020). Consequently, we conceptualize safety training engagement as the combination of optimal cognitive, emotional, and behavioral activity that drives motivation to learn and other training-approach behaviors. Drawing from the educational psychology literature, we concur that learner engagement has a multidimensional nature, with cognitive engagement considered as the mental effort invested in the training to think about and attend to the materials, behavioral engagement as actively participating in the training program, and affective or emotional engagement as a positive mental state in relation to the learning task at hand (Ben-Eliyahu et al., 2018). Using training engagement in a safety context fills a void in the research, which tends to model pre-training motivation, learning, and post-training motivation as the primary variables of interest. Safety training engagement as a within-training construct allows measurement and evaluation to venture into the learning process itself and enables diagnosis of in-situ effects of training design and delivery factors.

Training transfer is the focal outcome of training events and refers to the generalization and maintenance of learned knowledge and skills (Ford et al., 2018). Theoretically, training engagement is a proximal antecedent of learning that also affects training transfer. Without the experience of engaging with the training, training transfer cannot occur. Given that learning is affected by task engagement (Kanfer & Ackerman, 1989) and is malleable through the design and delivery features of training (Kanfer, 1990), engagement should be included within an enriched model of safety training transfer.

Adapting the seminal model outlined by Baldwin and Ford (1988) and recently consolidated by Ford et al. (2018), we propose three major categories that impact training transfer via training engagement: trainee factors that are specific to the individual (e.g., personality, beliefs, pre-training motivation), training factors that relate to how the training is designed and delivered (e.g., the level of engagement, use of adult learning principles), and contextual factors that arise from the team or organization (e.g., safety climate, safety training transfer climate). Outside safety training, meta-analytic studies have demonstrated that these categories of factors are most strongly related to training transfer (e.g., Blume et al., 2010). Within the context of safety training, design and delivery factors have been shown to be important in predicting transfer (Burke et al., 2006), and there is some evidence for contextual factors like safety training transfer climate (Krauss, 2005). Regarding personal characteristics, trainees' motivation (even after accounting for bias introduced by same-source and same-measurement contexts) has, among others, the highest correlation with learning and transfer (Blume et al., 2010). Consequently, pre- and post-training motivation is one of the most important variables that training designers and deliverers can target.

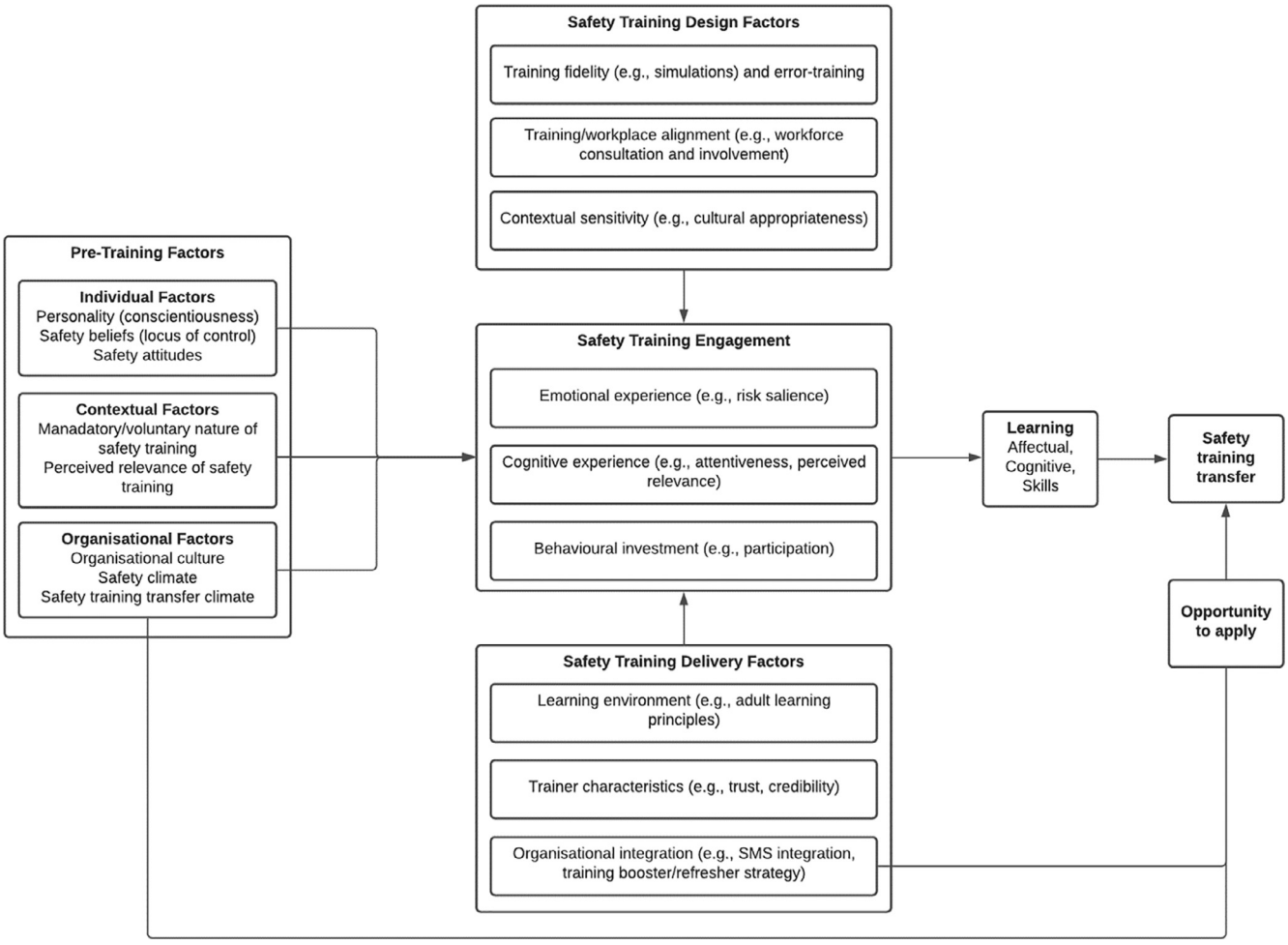

Fig. 1. Model of safety training engagement and transfer.

3. Review method

To develop a safety-contextualized understanding of each category, we scanned the safety training literature from 2010 onwards, focusing on specific and separate safety training delivered onsite or in occupational contexts rather than in classroom environments. Narrow search phrases including "safety training engagement," and "safety training transfer" were used across Scopus and Web of Science databases. An additional scan of Google Scholar search results (using the same search terms) was undertaken, and any unique articles not included in the first scan considered as part of the review. In total, 147 articles were sourced through these search activities. After removing duplicates and irrelevant articles by scanning the abstracts (i.e., published in a language other than English, non-peer reviewed), 57 articles were identified and reviewed in depth. A total of 38 articles had information that was relevant to the scope of this paper, as identified by the first author and a research assistant. Each of the 57 initial papers was evaluated as being relevant, irrelevant, or undecided by reviewing them in detail independently. Disagreements were then discussed and resolved. Articles were included if they (a) provided unique information not captured or repeated by other articles and (b) focused specifically on employee safety rather than other forms of safety (e.g., food safety). In the next section, we summarize this body of research across the categories formed by the safety training engagement and transfer model.

3.1. Safety training engagement

To transfer safety training successfully, trainees must learn and retain information. Safety training engagement is defined as a three-component psychological construct involving affective, cognitive, and behavioral elements in combination to optimize the energy and motivation directed towards the learning task. Such motivation to learn during safety training results in greater retention of knowledge, greater uptake of attitudinal change, and higher intention to engage in learned behaviors. Thereafter, training engagement promotes transfer through learning, and also via post-training motivation to apply/transfer (Naquin & Holton, 2002).

Some emerging findings from the safety training literature suggest that emotions play a central role in highlighting the salience of hazards and their corresponding risk levels. Cuing emotions such as fear or dread during safety training may deepen the learning process and encourage training transfer post-training (Burke et al., 2011). Cognitively, learners must be sufficiently motivated during the training process, as evidenced by attentional regulation (Kraiger et al., 1993). Behaviorally, learners experience engagement in safety training through active participation and involvement in learning activities (Casey et al., 2018). In safety training, engagement is likely to enhance learning because it can overcome suboptimal pre-training factors like negative safety attitudes or a weak safety climate.

3.2. Safety training transfer

Typically, safety training transfer is defined as the application of learned skills, generalization to work scenarios, and maintenance over time (Baldwin & Ford, 1988; Ford & Weissbein, 1997). Other aspects of training transfer may be important for safety training evaluation. Quantifying or qualifying the degree of transfer on the spectrum ranging from negative to positive would provide a useful success metric because it would highlight any intended interactions or variations in trained behavior that could actually decrease safety performance. Also, understanding whether the safety training only transfers to very similar contexts or also to very discrepant and diverse contexts may offer insights into why safety training can fail to produce the desired results, for example, during emergency events where conditions may be unique or short-lived.

As discussed previously, safety training transfer tends to be measured directly by attendance figures and evaluation forms and indirectly via injury and incident statistics. Safety training transfer should instead be measured using more nuanced metrics that could be staged to represent a growing embedding and exploration of additional skills and practices. For instance, initial transfer intention should be measured by utility reactions and motivation to apply learning. Short-term transfer can be measured by near-transfer evaluation—in other words, did trainees apply the learning in similar environments to what was trained? Mid-term evaluation should concentrate on far-transfer and long-term retention of key skills and concepts. Long-term evaluation can identify whether the training overall produced positive, zero, or neutral effects and also measure the factors that either supported or hindered the training being applied. Formative and summative evaluations can also be used together to identify improvements and lessons learned for future safety training designs.

3.3. Pre-training factors

Pre-training factors include trainee factors, contextual factors, and organizational factors. Trainee factors include personality traits, attitudes, and beliefs. Contextual factors specific to safety training (Krauss et al., 2014) include the mandatory or voluntary nature of the training (with mandatory training potentially reducing pre-training motivation to learn) and the perceived relevance of the safety training (particularly in the case of safety training content that is mandated by regulators or other government bodies). Finally, an organization creates a context in which safety training occurs. For instance, safety climate conveys the value and importance of safety behavior, which could dramatically affect pre-training characteristics such as safety attitudes and training motivation, affecting the level of training engagement (Krauss et al., 2014). Such factors can also be relevant after training by directly impacting post-training motivation to learn and subsequent training transfer. After training, the safety training transfer climate sends a strong signal to employees about whether the organization values the application and/or practice of what was learned during safety training (Krauss, 2005), again impacting training transfer.

3.3.1. Individual factors

3.3.1.1. Safety beliefs. Beliefs are internal schema or models around meaning and knowledge or, more practically, "how the world works" (Fishbein & Raven, 1962). A safety-related belief can therefore be a conviction about any aspect of how safety should be managed in an organization, such as implicit accident causation models (i.e., what causes an accident), what constitutes a hazard, and core self-beliefs regarding safety-specific locus of control. For instance, Krauss (2005), in an unpublished doctoral thesis, explored the interactive effects of work locus of control on safety training transfer. Although the findings were non-significant, they trended in the predicted direction and it was proposed that a safety-specific locus of control construct may have been more appropriate.

Nevertheless, in a training context, deep-seated beliefs are virtually impossible to shift and can act as a handbrake on any learning or desired change, reducing training engagement (Murphy & Mason, 2006). Understanding beliefs prior to safety training could enable a more nuanced and tailored approach to safety training whereby different 'streams' of learning are identified to target or amplify certain pre-existing beliefs.

3.3.1.2. Safety attitudes. Attitudes are evaluations toward people and objects in their environment (Ajzen, 2005). Safety attitudes can be a positive or negative assessment of a safety-specific object, person, or action (Lingard & Rowlinson, 2005), such as engaging in a particular safety practice, using a safety tool or process, or a judgment of safety personnel. Safety attitudes are relevant to safety training because they may affect not only behavior intention to engage fully with and participate in the training but also individuals' intentions to apply what was learned (Krauss, 2005). Safety attitudes can also change over the course of a training event, meaning that an initially unfavorable or resistant attitude could evolve into a more conducive one by the conclusion of the event. This has implications for the design of training; an initial "safety training readiness" module or specific structuring of the training may have a positive relationship with subsequent engagement during training (Casey, Krauss, & Turner, 2018).

3.3.1.3. Personality. Safety training is delivered in strong regulatory/compliance framework with a moral overtone. As such, it is reasonable to expect that conscientiousness may be the most relevant predictor. In the general training transfer literature, Huang and Bramble (2016) found that trait, state, and task-contingent conscientiousness affected learning and training transfer, detail-oriented and duty-bound employees may feel an obligation to pay attention and engage with safety training exercises, and also feel a stronger need to apply safety training afterwards. Only limited work has been done in this space. One study by Lingappa, Kiran, and Mathew (2020) explores the role of Big 5 personality traits in predicting safety training motivation to learn, motivation to transfer, and self-reported training transfer among employees from an Indian chemicals company. The authors found that conscientiousness and locus of control positively affected safety training transfer, whereas risk-taking propensity was negatively associated with transfer. In addition, Hogan and Foster (2013) conceptualized a facet-level personality construct called 'Trainable,' which referred to a person's tendency to accurately estimate their safety competence, openness to feedback, and engagement in learning. An association was found between this construct and supervisor safety performance ratings, but the study did not explore the relationships with safety training engagement or outcomes.

3.3.2. Contextual factors

3.3.2.1. Mandatory/voluntary safety training. A lot of safety training is typically mandated by government bodies, such as health and safety regulators, or required by client/principal contractor organizations in industries like construction (Krauss et al., 2014). The general transfer training literature suggests mandatory/voluntary training conditions might interact with personality traits (i.e., learning goal orientation) to influence learning outcomes (Gegenfurtner et al., 2016). Following the same logic, we propose that existing safety attitudes and beliefs may interact with voluntary/mandatory status to influence training engagement and training transfer. When safety attitudes and beliefs are favorable, mandatory status may matter less than if they are negative. Given

the prevalence of mandatory safety training, further research is needed to explore these relationships.

3.3.2.2. Perceived relevance. Many safety training programs suffer from a lack of domain specificity; for instance, many programs are designed as a one-size-fits-all solution where the audience needs and job characteristics are not taken into account (Casey, Krauss, & Turner, 2018). An example is when corporate areas from high-risk organizations participate in safety training that is primarily designed for their blue-collar operational colleagues. In these situations, the relevance of safety training is likely to result in audience disengagement and reduced uptake of learning. At the least, relevance will likely interact with training design factors to produce higher or lower attendee engagement in learning.

3.3.3. Organizational factors

3.3.3.1. Organizational culture. Fundamental beliefs and assumptions (Schein, 2010) relating to safety, such as what constitutes a hazard, what levels of risk are tolerable, and the nature of human relationships, are likely to affect training engagement, application and transfer. Studies in general training transfer have suggested that fundamental assumptions affect the attention and encoding of new information—contradictory or controversial ideas may even be ignored (Bunch, 2007). In relation to safety, training content that is misaligned with the dominant safety culture (i.e., assumptions surrounding such matters as hazards, risks, and interpersonal relationships, such as speaking up and stopping an unsafe act among coworkers) may be dismissed or ignored, leading to lower learning engagement. Given that the definition of safety is subjective (Dekker, 2019) and influenced by both individual- and group-level beliefs, the dominant culture operating within the trainee's local context could act as an information filter, highlighting or emphasizing some information and dismissing or downplaying other information that is misaligned or in conflict with the norms, values, and beliefs endorsed by the group. Culture is likely to also play a role in subsequent transfer because dominant norms may decrease intention to apply behaviors if they are not established or embedded in the team. Potentially, safety training should be conducted with intact teams to ensure social norms change.

3.3.3.2. Safety climate. Safety climate refers to the perceived value and importance of safety in an organization, as inferred through perceptions of policies, procedures, and practices (Zohar, 2010). Safety climate may affect the transfer of safety training by providing a broader social context that infers the priority of such training and the overall importance of safety. Indeed, Burke, Chan-Serafin, Salvador, Smith, and Sarpy's (2008) investigations across 68 organizations revealed that safety climate moderated the safety training–incidents relationships, with more positive safety climates amplifying reduction of incidents. Safety climate is a powerful contextual factor because it can influence pre-training factors like safety attitudes and motivation, within-training factors like motivation to learn (impacting engagement), and also post-training factors like motivation to apply (Griffin & Curcuruto, 2016).

3.3.3.3. Safety training transfer climate. In the general training literature, training transfer climate refers to the overarching priority of training, based on workers' perceptions of how valued and important it is to apply what is learned, with a focus on social support to apply (Baldwin & Ford, 1988; Rouillier & Goldstein, 1993; Tracey, Tannenbaum, & Kavanagh, 1995). It is distinct from safety climate because the former is a narrow perception of the importance and value of safety training, whereas safety climate refers to the higher order value of safety in general. Safety training may have a different priority compared to regular training. It may be considered less important or potentially wasting experienced employees' time. Thus, the social transfer environment in which safety training occurs is crucial. In an unpublished thesis, Krauss (2005) developed a measure of safety training transfer climate, finding that factors such as supervisor recognition for applying safety training, management encouragement of safety training, and opportunities to apply safety training indeed created a shared social context that influenced the transfer of safety knowledge.

3.4. Safety training design factors

Referring to the nature of how the training is created, training design factors are a prime target to improve safety training transfer. An interesting development in transfer research and practice is the use of technology in safety training to increase the level of fidelity, potentially triggering strong emotional and cognitive responses to embed learning (e.g., Bhandari & Hallowell, 2017). The alignment between "work as trained" and "work as done" is also likely to influence learner engagement and transfer. Involving workers in the design and development of safety training is likely to create greater ownership and enhance the learners' engagement. Finally, much safety training is delivered to diverse groups in terms of literacy and cultural background (e.g., Arcury et al., 2014). Ensuring the training design reflects these important differences will ensure that learners are suitably engaged.

3.4.1. Training fidelity and error training

Technology holds much promise when it comes to improving safety training engagement via fidelity. Much of safety is practical and hands-on, involving the development of skills such as hazard recognition, implementation of control measures, and safe work practices. Technology that simulates real-world conditions and gives a more nuanced and lifelike representation of safety scenarios is not only more engaging but also associated with better learning outcome in comparison to traditional classroom didactical training. In safety training, emerging evidence suggests that immersive injury simulations can induce strong emotions, which in turn increases interest in training content and contributes to risk-averse behavioral transfer Bhandari, Hallowell, & Correll (2019). Subsequent research with virtual reality in construction settings by Bhandari and colleagues (2020) found that emotions induced by simulated environments predicted higher risk perception and more effective safety decision-making.

Mixed-reality is an example of such technological advancement. In Hasanzadeh, de la Garza, and Geller's (2020) recent study, workers installed shingles onto a sloped roof (physical task) while at a simulated height of two meters (virtual environment). The experimenters manipulated various hazards and measured physiological markers to evaluate "presence" or mindful attention to the task. Others have investigated the use of building information modeling (BIM) in construction safety training contexts and found that compared to lectures, BIM-supported training resulted in greater knowledge transfer (Ahn, Kim, Park, & Kim, 2020). Finally, Chittaro, Corbett, McLean, and Zangrando (2018) explored the use of virtual reality to improve aircraft safety procedures. Virtual-reality-trained participants exhibited significantly faster life-vest donning and fewer errors than traditionally-briefed ones. Virtual reality (VR) technologies seem to have special relevance and utility in the context of emergency training, a form of safety training that concentrates on evacuation and other drills in response to incidents. In a systematic review published in the information sciences literature, Feng and colleagues (2018) put forward a model to inform the design and evaluation of virtual technologies in this setting. The study conceptualizes this use of VR equipment as a 'serious game' whereby deep learner engagement (as represented by our model through emotional, cognitive, and behavioral components) results in deeper learning and higher rates of post-training

application. From a neuroscience perspective, inducing emotions through immersive virtual environments may facilitate stronger neuronal connections and associations between stimulus–response via the amygdala. Further, deeper learning of motor movements and physical skills required (e.g., operating a fire extinguisher) may be stimulated in the cerebellum through the immersive and feedback-rich environment of VR (as shown in healthcare and rehabilitation settings; e.g., Kim, Schweighofer, & Finley, 2019; Mao et al., 2014).

Gamification can also boost training engagement by enabling more detailed performance feedback to occur. Highlighting the use of technology to drive personalized training feedback, Jeelani, Han, and Albert (2018) evaluated the use of eye-tracking technology in construction, with hazard detection likelihood scores being used to improve safety performance among workers. Liang, Zhou, and Gao (2019) explored gamification in the mining industry and found that an immersive gaming environment using off-the-shelf equipment (i.e., HTC Vive and Unity 3D engine) improved miners' safety awareness and risk-aversion. Similarly, in one systematic review conducted in the construction industry, the authors found that gamified training as well as other computer aided technologies (simulations, augmented reality, virtual reality, mixed-reality) improved trainee engagement (Gao, Gonzalez, & Yiu, 2019).

Online safety training is gaining increasing traction, especially for mandatory site inductions in the high-risk domains such as construction and manufacturing, and represents a vehicle for greater individualization of safety training by allocating courses based on training needs analysis (Trout, 2016). Limited research has been done on online safety training, but one study has shown differences between older and younger workers (Wallen & Mulloy, 2006), which may be due to differing levels of computer self-efficacy or anxiety (Chen, 2017), innovativeness (Jokisch et al., 2020), and human–computer interaction factors like ease of use (Tsai et al., 2017)—all of which have been associated with age (older age adversely affects these variables). Early research has shown that less information-dense and visualized online safety training (e.g., videos, graphics, audio files) performed the best at stimulating learning across age groups (Wallen & Mulloy, 2006). Others have promoted the utility of blended learning for safety, which combines online modules with face-to-face activities. Specifically, Stuart (2014) found that for furniture manufacturing trainees, the anxiety and intimidation of the workplace setting, and practical exercises could be reduced through giving trainees access to prior online safety modules. Overall, more research is needed to understand how to design and deliver effective online safety training; however, general user experience principles founded on aesthetics, usability, and usefulness as per mainstream technology acceptance and computer anxiety models are good starting points for practitioners.

Indeed, blended learning is widely considered to be the most popular and effective mode of corporate training due to its flexibility, efficiency, and stimulation of continuous learning among students (Rasheed, Kamsin & Abdullah, 2020). Yet, and of relevance to safety training considering pre-training factors like existing safety beliefs and attitudes, blended learning has four key challenges: incorporating flexibility, stimulating student interaction, facilitating deep learning, and fostering an effective learning climate (Boelens, De Wever & Voet, 2017). As no systematic review of online or blended safety training research yet exists, research is required to clarify how the design of online safety training can be optimized. Cross-disciplinary collaboration among safety scientists, educators, and human–computer interaction specialists will be required.

Burke and colleagues (2011) conducted a meta-analysis on existing safety training studies and found that when the hazard (s) to be trained against were deemed higher risk, safety training was seen as more engaging. This effect occurs because the salience of hazards induces "dread" and elevates subjective perceptions of risk, resulting in higher learning engagement. These meta-analytic results are supported by several subsequent studies involving technology. For instance, Namian, Albert, Zuluaga, and Behm's (2016) study in construction found that engaging training combined with salient depictions of hazards resulted in more effective transfer. Gummesson (2016) discovered the utility of QR (quick response) codes in safety training for students, allowing them to view more detailed and vivid imagery of hazards. Loosemore and Malouf (2019) recommended that construction safety training should use more engaging and salient depictions of risk—ideally using technology.

Much has been written about the benefits of training through error exploration—it enables people to create deeper and more robust knowledge schema and develop more accurate mental models of how underlying processes or work systems operate (Keith & Frese, 2008). In such general error training, the protocol is to allow trainees to actively explore target activities or processes, encourage them to make errors and recover performance, and provide constructive and positive feedback. In high-risk settings, challenges such as automation create intractable systems that can escape employees' capacities to comprehend and develop an accurate situational awareness (Hollnagel, Wears, & Braithwaite, 2015). Using error-based learning may counter this issue and allow operators to learn how complex systems work and, importantly, how they fail.

Developing skills "at the edge" and even over the boundary of safety has been identified as a key strategy to make further improvements in safety performance in today's complex and dynamic work environment (Rasmussen, 1997). In health care, Browne et al. (2019) found that error training combined with bias-reduction strategies were effective at improving health-care providers' critical-thinking skills and subsequent error-management and safety performance. Finally, Choi, Ahn, and Seo (2020) used virtual reality to give forklift drivers the opportunity to make and learn from errors during driving, which boosted their situational awareness and safety performance. More work is needed to determine the impact of error-based learning on safety training engagement, particularly in the context of complex systems.

3.4.2. Training/workplace alignment

In many countries, employers are required by law to consult with workers about hazards and to inform the development of events like safety training (e.g., the Work, Health & Safety Act, 2011 in Australia). The purpose of this consultation is to ensure that the expertise of workers, who do the job on a daily basis, is incorporated into safety decisions made by management and ultimately results in more effective safety interventions (Safe Work Australia, 2018). When it comes to safety training, involving workers in its design and development may increase their engagement. One study in the agriculture industry found reduced training impact due to inadequate consideration of farmers' daily tasks, work context, and learning needs (Holte & Follo, 2018). The training was described as abstract, theoretical, and out of touch with farmers' needs and language. Others have found similar results, possibly due to a lack of consultation and involvement of the audience in the program design (Casey et al., 2018). In a recent study, Vigoros, Caffaro, and Cavallo (2020) tested a user-centered design model to develop visual safety tools for migrant farming workers. A significant difference in training satisfaction was found between the user-centered design group and the control group, highlighting the importance of involving workers in the development of safety training if learner engagement is to be maximized.

3.4.3. Contextual sensitivity

With an increasingly global workforce in safety–critical settings (Clarke, 2003), differences in national culture or ethnic background are likely to influence the effectiveness of safety training. National culture may affect learner engagement. Differences in language ability and interpretation of training materials are likely issues to explore. In a study investigating the design of multicultural safety training, Kovacic and Cunningham (2019) found that engaging delivery, combined with purposeful efforts to instill cultural respect into the training environment, and hands-on practical skill development and assessment activities tended to produce the best learning outcomes for multicultural workforces. Digging deeper into cultural beliefs, Yorio, Edwards, and Hoeneveld (2019) put forward several safety-specific propositions around Hofstede's (1980) cultural dimensions. Of relevance to safety training transfer, dimensions such as uncertainty avoidance (i.e., extent to which groups rely on norms and rules; Hofstede, 1980) may affect the transfer of certain types of training. For cultures with high uncertainty avoidance, safety training that focuses on legislation, standards, and rules may be more accepted and, hence, more likely to be transferred and applied. Burke et al. (2008) found that uncertainty avoidance was negatively related to safety training transfer in a meta-analytic study, but the type of training was not explored.

3.5. Training delivery factors

When corporate training uses principles such as adult learning (Knowles, 1996), transfer is improved (Burke & Hutchins, 2007). Adult learning includes strategies such as involving workers in the training program, scaffolding or building on existing knowledge, and encouraging adults to set their own learning tactics. In safety settings, particularly construction, safety training is often described as mundane, standardized, and infrequently incorporates adult learning principles (Bhandari et al., 2019). A meta-analysis conducted by Burke and colleagues (2006) found that more engaging and dynamic safety training results in better engagement and transfer. More recently, a study in the construction industry found that more engaging safety training methods resulted in attendees identifying more hazards and perceiving higher risk than those who attended less engaging training (Namian, Albert, Zuluaga, & Jaselskis, 2016). Again, in construction, Eggerth, Keller, Cunningham, and Flynn (2018) found that safety training that included narratives and discussion questions produced better learning than those without engaging methods.

Several individual studies in high-risk settings have replicated these results, showing that engaging in safety training results in higher risk salience, greater learning, and boosted application of learning on return to the workplace (e.g., Eggerth et al., 2018; Namian, Albert, Zuluaga, & Jaselskis, 2016). Trainers may carry different levels of credibility in the eyes of attendees, depending on whether they have an operational background or a safety science background. Indeed, operational safety professionals and trainers may more readily build trust and rapport with workers and deliver more enriched examples of targeted behaviors. Finally, integration of organizational processes and systems with safety training could impact not only the learning process but also the post-training motivation to learn through reinforcement and boosting of learned concepts and skills.

3.5.1. Learning environment

Active participation during safety training has long been established as a predictor of transfer. Through their seminal meta-analysis, Burke and colleagues (2006) found that safety training designed with adult learning principles and encouraged a high degree of involvement and participation tended to be more successful. Participating in safety training is likely to enhance its effectiveness because much of it is skill-based and so requires some behavioral investment (Krauss et al., 2014). By actively participating in safety training, attendees are more likely to develop behavioral routines and refine their performance, ideally in some sort of constructive feedback environment.

In a qualitative case study exploring corporate trainers' strategies to engage attendees, Arghode and Wang (2016) discovered that trainers use several different strategies. These strategies include being trainee-centered (e.g., providing interesting and relevant examples), using entertaining and interesting instruction techniques (e.g., humor), using a diverse range of instructional types (e.g., kinesthetic, didactic), encouraging trainees to participate in the session (e.g., role-play), and building rapport early in the session to maintain trust (e.g., an introductory ice-breaker activity). Further research is needed to explore the specific skills and strategies employed by safety trainers to create a positive learning environment that boosts engagement.

3.5.2. Trainer characteristics

Little research has been done on the characteristics of trainers themselves and their impact on safety training engagement. Burke and Hutchins' (2008) qualitative study in the general training literature found that trainers' subject matter knowledge, professional experience, and knowledge of learning principles were important factors. For safety training, trainer credibility may be particularly important. For many workers, safety training is seen as abstract or detached from the lived reality of their jobs (Holte & Follo, 2018). When a trainer is seen as an outsider or non-credible in the eyes of attendees, their willingness to engage in learning may be reduced. This may be related to the development of trust and rapport between trainer and trainee, similar to the concept of therapeutic alliance in counseling psychology (Elvins & Green, 2008). An element of trust is perceived competence or ability (Mayer, Davis & Schoorman 1995). Butler, Reed, and Le Grice (2007) found that vocational training in small business settings was important for knowledge transfer and improved performance.

3.5.3. Organizational integration

Integrating safety training concepts and practices within an existing safety management framework is likely to not only create additional opportunities to transfer, but also send signals regarding the priority and importance of such training, contributing positively to the safety training transfer climate. In the training transfer literature, the presence of an evaluation framework encourages transfer post-training (Hutchins, Burke, & Berthelsen, 2010). Measuring safety training using a combination of "lead and lag" indicators that go beyond training attendance and injuries/accidents is crucial to learn more about what promotes engagement and transfer. Training 'booster' interventions have thus far shown inconsistent effects on long-term transfer in the general training literature. In the general training literature, a strategy borrowed from clinical psychology called "relapse prevention" has been evaluated several times with inconsistent results (Hutchins & Burke, 2006). In safety settings, the results are also mixed. Casey and colleagues (2018) experimented with a training transfer relapse prevention module within the fishing industry. The module consisted of a structured checklist and the opportunity for attendees to brainstorm how they will overcome barriers to transfer. Because the overall training failed to show an effect on outcomes, the impact of the relapse prevention was not discernible. More work is needed to elucidate the impact of relapse prevention in safety training. Regarding booster training, the results are more positive. Kovacic and Cunningham (2019) and Ruttenberg and Rice (2019) explored the effectiveness of refresher training and found that participants apply concepts more often if refresher training is used. Boosters

may prevent knowledge decline in safety training given reduced opportunities to apply learnings.

3.6. Opportunity to apply

Having the opportunity to apply training is one of the most important predictors of training transfer (Burke & Hutchins, 2007). Opportunities to apply can either be passive or active. Passive opportunities are when supervisors or managers create time for employees to practice learned skills, such as freeing up work commitments. Active opportunities to apply are when either transfer is directed/encouraged (e.g., practicing safety conversations during a Toolbox Talk) or is required on the job (e.g., an emergency event happens). The opportunity to apply is particularly important for safety training because some types of safety education cannot be directly practiced in the workplace, such as specific emergency events (Krauss et al., 2014). Implementing virtual reality technologies and simulations could be a promising way to provide opportunities to apply safety training in the future, and specifically for emergency training to provide simulated opportunities to use learned skills, maintain knowledge, and increase awareness and vigilance under times of stress (Feng et al., 2018). VR-based training could even be used to give employees opportunities to practice multiple roles during emergency events, providing cross-training and redundancy in the event a person in a critical role (e.g., fire wardens and first-aiders) becomes incapacitated or is unavailable.

4. Discussion

In this paper, we have outlined an enriched safety training transfer model. We reviewed the past decade of safety training literature to inform the development of this model, with a focus on contemporary topics like the use of technology in the safety learning space. This review takes stock of the current safety training landscape with a view to encouraging further research and more effective practice in the design and delivery of safety training, with a view to optimizing learner engagement and subsequent transfer. Several proposed factors specific to safety training have been proposed and warrant further research: trainer credibility, training fidelity, safety management system integration, and others.

4.1. Theoretical implications

This paper highlights a distinction between learner engagement and transfer. In the general training transfer and also safety-specific domain, there is a focus on transfer as an outcome of the 'black box' of intra-training factors. Separating learner engagement from this process and considering the roles of training design and delivery, as well as pre-training factors, may stimulate more nuanced and practical research. Although we know a lot about what predicts safety training transfer, less is known so far about how engagement can be increased, and specifically, which elements of engagement (emotional, cognitive, and behavioral) are most important within the context of different types of safety training.

Safety training warrants a particular focus when it comes to optimizing training transfer. Applying an individually-focused model like the theory of reasoned action or planned behavior (Fishbein & Azjen, 1975) suggests that safety attitudes, norms, and behavioral control will influence intention to use safety training. From an organizational perspective, group-level phenomena like safety culture and climate have been shown to affect training transfer, which points to the importance of thinking globally around training implementation.

Recent work done on the individualization of safety training suggests that there is a complex interaction between personal characteristics (e.g., personality and beliefs), training design and delivery factors, and contextual factors (e.g., safety training transfer climate). Just as the general safety climate literature has started to examine the complex interplay between individual, group, and organizational factors (e.g., Beus, Bergman, & Payne, 2016), safety training transfer research could also benefit from this approach. For example, Beus et al. (2010) found that organizational tenure attenuated safety climate strength in a non-linear fashion—employees with less tenure or who are less open to experience may be less affected by the social context, and so alternative strategies will need to be deployed.

In our model, safety training type is positioned as an important moderating or contextual variable. "Straightforward" safety training that concentrates on declarative knowledge for low-risk hazards is likely best done using didactic and traditional lecture-based methods (Burke et al., 2006). For problem-solving training, weaving in high-fidelity technologies and error-based learning will likely improve transfer outcomes. Further research is needed to examine the configurations of transfer factors required to optimize different types of safety training.

4.2. Practical implications

Several practical implications are apparent following this review. These implications have been arranged into actions that organizations can undertake either prior to, during, or following safety training implementation.

4.2.1. Before training

Before training, it would be advantageous to measure trainees' pre-existing safety characteristics (e.g., attitudes, beliefs) and use this information to stream attendees into different levels or types of training interventions. For instance, if safety attitudes are negative or neutral, an additional high impact and energy module might be effective at creating increased readiness to change and overall engagement in the learning.

We recommend that organizations measure and improve their safety training transfer climate before training is implemented to ensure the conditions for transfer are optimized. Measurement could be done by drawing on a published scale of training transfer, and adapting to the safety context, or using the safety-specific scale developed by Krauss (2005). Improvements to the safety training transfer climate could be achieved through the following interventions: (a) supervisor training that concentrates on pre- and post-training conversations around the value and importance of safety training, (b) targeted communications from senior management referring to the specific safety training and its benefits/importance, (c) developing post-training verification of competence and supportive conversations programs, (d) aligning safety training application with performance recognition programs, and (e) ensuring workers are given time at work to prepare for and practice safety training.

Preparatory communication should be delivered to ensure trainees are familiar with the reasons why the training is being delivered and consider using strategies to induce a learning goal orientation (e.g., framing the messages as a chance for self-betterment or improvement rather than achieving a grade or competency above others). Such work would lay a foundation for positive learner engagement.

Another strategy that organizations could adopt to improve safety training engagement is to develop a pre-training readiness module, which could include: messages of support and encouragement from senior leaders (e.g., video message), activities designed to measure training readiness, such as training anxiety, attitudes

toward safety training, and include targeted "mini-interventions," a detailed overview of the training (including its purpose, benefits, and objectives), and, finally, targeted pre-work such as condensed readings of the topic or 1–2 key questions for trainees to consider prior to arriving at the training (e.g., asking attendees to take a photo of what makes them feel safe in their work environment).

Consultation is important to the design of effective and relevant safety training. Specifically, designers should involve workers in the design and development of training content and delivery methods. Resources such as health and safety representatives can be leveraged to keep the consultation manageable and targeted. Such consultation will help to increase the alignment between what is taught during safety training with what practices actually occur on the job (aligning work as imagined with work as done). Higher engagement in the learning is likely to result.

From a broader perspective, the organization should consider coupling safety climate improvement initiatives to major safety training events because the broader team and organizational social context will influence engagement and transfer. There are likely to be positive synergies between safety climate discovery and safety training, particularly if there is alignment between the opportunity areas identified by a climate survey and the areas targeted by training. Finally, organizations should look for ways to "declutter" safety training by removing redundant or irrelevant sections or parts that add little/no value to workers and reduce engagement—this can be achieved systematically by conducting formative training evaluations with a pilot group.

4.2.2. During training

The correct design of safety training can significantly enhance engagement. To optimize learning, designers should consider the type of safety training to be delivered and what combination of transfer factors are more important to optimize transfer performance and maintain cost/benefit efficiencies. For fundamental knowledge and skills, traditional techniques like lectures or group-based learning, the use of narratives or story-telling techniques, and discussion/application questions will be helpful. For hazard recognition, organizations should try to apply technology such as virtual reality and augmented reality. For problem-solving and decision-making, organizations could use error management and simulation training activities. And, finally, for empowerment, we recommend that organizations draw on engaging techniques like role-playing and expert demonstrations, providing examples of effective/ineffective performance, and providing detailed feedback on training performance. Research on this topic is in its infancy, but it may help to use immersive virtual, augmented, or mixed-reality technologies when the objective of the training is to improve hazard recognition, appraisal, and/or appreciation of risk where high-fidelity creates engagement and emotional arousal in response to target stimuli.

Biofeedback technologies could be used to improve learner engagement and transfer. For instance, eye-tracking can help inform what people need to learn about in the area of hazard recognition training, and heart rate variability monitoring can be used to provide ongoing feedback about the application of stress and distraction management techniques. Further, designers can use high-fidelity imagery and other media to induce strong emotional responses to high-risk hazards; however, attendees may need to be psychologically prepared if the imagery is graphic or potentially upsetting.

4.2.3. After training

Combining safety training concepts with existing routines and processes embedded within management systems is likely to cue learned content and boost transfer. In other words, organizations could identify ways that safety training can be integrated within existing SMS and safety processes; for example, embedding training language or concepts into risk assessment forms or modifying incident investigation processes to include appreciative inquiry skills learned during safety training may be beneficial.

An area that requires additional research but nonetheless seems important for transfer is refresher training. One recommendation is to time refresher training to ensure learning is retained and embedded. To date, only a few studies have been conducted on the design and timing of refresher training—one study by Kluge and Burkolter (2012) found that physical practice of a process control task resulted in better learning retention and transfer than a "symbolic rehearsal" or written refresher task. These refreshers took place 2–3 weeks after the initial training. In our view, ensuring a safety training refresher booster approximately one month after the initial training event is probably optimal for long-term retention. However, further work is needed to identify more specific guidance around refresher timing.

Importantly, organizations should identify how the training transfer will be measured and use a range of metrics that go beyond names and numbers of attendees, incident reductions, and evaluative "smile sheets." Organizations should consider whether it is possible to measure safety training transfer using behavioral observations, diarized feedback, pulse surveys, and/or competency evaluations. Additional training metrics could include motivation and confidence to transfer/apply learning, actual training application, type of transfer achieved (near/far), and impact of training on safety performance (positive, negative, neutral). Finally, organizations should monitor the transfer of training through surveys and/or observations of training application—identifying and ameliorating barriers or challenges to transfer.

Numerous training transfer studies have shown that social support is critical (e.g., Burke & Hutchins, 2007, 2008). For organizations delivering safety training, target direct leaders and supervisors to ensure there is a strategy to provide social support for safety training transfer; at a minimum, supervisors should be holding post-training conversations with workers about how to apply learning, what they learned, and how ongoing safety development can occur.

4.3. Future research directions

An interesting direction of future research concerns the dynamic modeling of safety transfer over time. Too often, training transfer is operationalized as a binary phenomenon (i.e., either it happens, or it does not) and as a product or outcome of the training delivery factors combined with attendee and contextual factors (Bell & Kozlowski, 2010). Instead, transfer should be thought of as a process in itself (Foxon, 1997), one that unfolds and fluctuates over time with the ebb and flow of various predictors such as supervisor support (Olenick, Blume, & Ford, 2020). With respect to safety training transfer, modeling the organizational or even team safety climate as a dynamic variable that affects training application could be a powerful way to advance the field. Given that safety climate is a dynamic variable that is both a leading indicator ahead of incidents and a lagging indicator in response to incidents (Payne, Bergman, Beus, Rodríguez, & Henning, 2009), taking multiple measurements in parallel to transfer behaviors could help to explain why some safety training fails to be applied in practice.

5. Conclusion

Although safety training is a mainstay of many organizations' safety management systems, not all safety training is effective. Drawing from the general training transfer literature and considering the application of these findings to safety training in light of its

specific features and challenges, there is clearly no one-size-fits-all solution. Safety training transfer requires a multi-pronged approach that considers the trainee, training, and contextual factors, their interactions, and how individual characteristics should be used to inform the organization's training transfer strategy. As more research is done on this topic, organizations will learn about how safety training can be optimized to produce the best financial returns and the most effective improvement in safety performance.

Acknowledgment

This research was partially funded by Urban Utilities, Queensland, Australia.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsr.2021.06.004.

References

Asterisked papers were included in our 10-year review of safety training research

*Ahn, S., Kim, T., Park, Y.-J., & Kim, J.-M. (2020). Improving effectiveness of safety training at construction worksite using 3D BIM simulation. *Advances in Civil Engineering, 2020*, 1–12. https://doi.org/10.1155/2020/2473138.

Ajzen, I. (2005). *Attitudes, personality, and behavior*. London: McGraw-Hill Education.

Arcury, T. A., Nguyen, H. T., Summers, P., Talton, J. W., Holbrook, L. C., Walker, F. O., ... Quandt, S. A. (2014). Lifetime and current pesticide exposure among Latino farmworkers in comparison to other Latino immigrants. *American Journal of Industrial Medicine, 57*(7), 776–787.

Arghode, V., & Wang, J. (2016). Exploring trainers' engaging instructional practices: A collective case study. *European Journal of Training and Development, 40*(2), 111–127.

Baldwin, T. T., & Ford, J. K. (1988). Transfer of training: A review and directions for future research. *Personnel Psychology, 41*(1), 63–105.

Baldwin, T. T., Kevin Ford, J., & Blume, B. D. (2017). The state of transfer of training research: Moving toward more consumer-centric inquiry. *Human Resource Development Quarterly, 28*(1), 17–28.

Bell, B. S., & Kozlowski, S. W. J. (2010). Toward a theory of learner-centered training design: An integrative framework of active learning. In S. W. J. Kozlowski & E. Salas (Eds.), *SIOP organizational frontiers series. Learning, training, and development in organizations* (pp. 263–300). Routledge/Taylor & Francis Group.

Ben-Eliyahu, A., Moore, D., Dorph, R., & Schunn, C. D. (2018). Investigating the multidimensionality of engagement: Affective, behavioral, and cognitive engagement across science activities and contexts. *Contemporary Educational Psychology, 53*, 87–105.

Beus, J. M., Bergman, M. E., & Payne, S. C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident Analysis & Prevention, 42*(5), 1431–1437.

*Bhandari, S., & Hallowell, M. R. (2017). Emotional engagement in safety training: Impact of naturalistic injury simulations of the emotional state of construction workers. *Journal of Construction and Engineering Management, 143*(12), 04017090. 10.1061(ASCE)CO.1943-7862.0001405.

*Bhandari, S., Hallowell, M. R., & Correll, J. (2019). Making construction safety training interesting: A field-based quasi-experiment to test the relationship between the emotional arousal and situational interest among adult learners. *Safety Science, 117*, 58–70. https://doi.org/10.1016/j.ssci.2019.03.028.

*Bhandari, S., Hallowell, M. R., Boven, L. V., Welker, K. M., Golparver-Fard, M., & Gruber, J. (2020). Using augmented virtuality to examine how emotions influence construction-hazard identification, risk assessment, and safety decisions. *Journal of Construction and Engineering Management, 146*(2), 04019102. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001755/.

Blume, B. D., Ford, J. K., Baldwin, T. T., & Huang, J. L. (2010). Transfer of training: A meta-analytic review. *Journal of Management, 36*(4), 1065–1105.

Boelens, R., De Wever, B., & Voet, M. (2017). Four key challenges to the design of blended learning: A systematic literature review. *Educational Research Review, 22*(1), 1–18.

*Brahm, F., & Singer, M. (2013). Is more engaging safety training always better in reducing accidents? Evidence of self-selection from Chilean panel data. *Journal of Safety Research, 47*, 85–92. https://doi.org/10.1016/j.jsr.2013.09.003.

*Browne, A. M., Deutsch, E. S., Corwin, K., Davis, D. H., Teets, J. M., & Apkon, M. (2019). An IDEA: Safety training to improve critical thinking by individuals and teams. *American Journal of Medical Quality, 34*(6), 569–576. https://doi.org/10.1177/1062860618820687.

Bunch, K. J. (2007). Training failure as a consequence of organizational culture. *Human Resource Development Review, 6*(2), 142–163.

Burke, M. J., Chan-Serafin, S., Salvador, R., Smith, A., & Sarpy, S. A. (2008). The role of national culture and organizational climate in safety training effectiveness. *European Journal of Work and Organizational Psychology, 17*(1), 133–152.

Burke, L. A., & Hutchins, H. M. (2007). Training transfer: An integrative literature review. *Human Resource Development Review, 6*(3), 263–296.

Burke, L. A., & Hutchins, H. M. (2008). A study of best practices in training transfer and proposed model of transfer. *Human Resource Development Quarterly, 19*(2), 107–128.

Burke, M. J., Salvador, R. O., Smith-Crowe, K., Chan-Serafin, S., Smith, A., & Sonesh, S. (2011). The dread factor: How hazards and safety training influence learning and performance. *Journal of Applied Psychology, 96*(1), 46–70.

Burke, M. J., Sarpy, S. A., Smith-Crowe, K., Chan-Serafin, S., Salvador, R. O., & Islam, G. (2006). Relative effectiveness of worker safety and health training methods. *American Journal of Public Health, 96*(2), 315–324.

Butler, A., Reed, M., & Le Grice, P. (2007). Vocational training: Trust, talk and knowledge transfer in small businesses. *Journal of Small Business and Enterprise Development, 14*(2), 280–293.

*Casey, T. W., Krauss, A. D., & Turner, N. (2018). The one that got away: Lessons learned from the evaluation of a safety training intervention in the Australian prawn fishing industry. *Safety Science, 108*(1), 218–224. https://doi.org/10.1016/j.ssci.2017.08.002.

*Chittaro, L., Corbett, C. L., McLean, G. A., & Zangrando, N. (2018). Safety knowledge transfer through mobile virtual reality: A study of aviation life preserver donning. *Safety Science, 102*, 159–168. https://doi.org/10.1016/j.ssci.2017.10.012.

*Choi, M., Ahn, S., & Seo, J. (2020). VR-based investigation of forklift operator situation awareness for preventing collision accidents. *Accident Analysis and Prevention, 136*, 105404. https://doi.org/10.1016/j.aap.2019.105404.

Clarke, S. (2003). The contemporary workforce: Implications for organisational culture. *Personnel Review, 32*(1), 40–57.

Dekker, S. (2019). *Foundations of safety science*. Miami: CRC Press.

*Eggerth, D. E., Keller, B. M., Cunningham, T. R., & Flynn, M. A. (2018). Evaluation of Toolbox safety training in construction: The impact of narratives. *American Journal of Industrial Medicine, 61*(12), 997–1004. https://doi.org/10.1002/ajim.22919.

Elvins, R., & Green, J. (2008). The conceptualization and measurement of therapeutic alliance: An empirical review. *Clinical Psychology Review, 28*(7), 1167–1187.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Fishbein, M., & Raven, B. H. (1962). The AB scales: An operational definition of belief and attitude. *Human Relations, 15*(1), 35–44.

Ford, J. K., Baldwin, T. T., & Prasad, J. (2018). Transfer of training: The known and the unknown. *Annual Review of Organizational Psychology and Organizational Behavior, 5*(1), 201–225.

Ford, J. K., & Weissbein, D. A. (1997). Transfer of training: An updated review and analysis. *Performance Improvement Quarterly, 10*(2), 22–41.

Foxon, M. (1997). The influence of motivation to transfer, action planning, and manager support on the transfer process. *Performance Improvement Quarterly, 10*, 42–63.

*Freitas, A. C., Silva, S. A., & Santos, C. M. (2017). Predictors of safety training transfer support as in-role behavior of occupational health and safety professionals. *European Journal of Training and Development, 41*(9), 776–799. https://doi.org/10.1108/EJTD.03.2017.0024.

Freitas, A. C., Silva, S. A., & Santos, C. M. (2019). Safety training transfer: The roles of coworkers, supervisors, safety professionals, and felt responsibility. *Journal of Occupational Health Psychology, 24*(1), 92–107. https://doi.org/10.1037/ocp0000125.

*Gao, Y., Gonzalez, V. A., & Yiu, T. W. (2019). The effectiveness of traditional tools and computer-aided technologies for health and safety training in the construction sector: A systematic review. *Computers & Education, 138*, 101–115. https://doi.org/10.1016/j.compedu.2019.05.003.

Gegenfurtner, A., Könings, K. D., Kosmajac, N., & Gebhardt, M. (2016). Voluntary or mandatory training participation as a moderator in the relationship between goal orientations and transfer of training. *International Journal of Training and Development, 20*(4), 290–301.

Griffin, M. A., & Curcuruto, M. (2016). Safety climate in organizations. *Annual Review of Organizational Psychology and Organizational Behavior, 3*(1), 191–212.

Griffin, M. A., & Neal, A. (2000). Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of Occupational Health Psychology, 5*(3), 347–358.

*Gummesson, K. (2016). Effective measures to decrease air contaminants through risk and control visualization—A study of the effective use of QR codes to facilitate safety training. *Safety Science, 82*, 120–128. https://doi.org/10.1016/j.ssci.2015.09.011.

Harvey, P. D., Balzer, A. M., & Kotwicki, R. J. (2020). Training engagement, baseline cognitive functioning, and cognitive gains with computerized cognitive training: A cross-diagnostic study. *Schizophrenia Research: Cognition, 19* 100150.

Hasanzadeh, S., de la Garza, J. M., & Geller, E. S. (2020). How sensation-seeking propensity determines individuals' risk-taking behaviors: Implication of risk compensation in a simulated roofing task. *Journal of Management in Engineering, 36*(5). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000813 04020047.

Hofstede, G. (1980). Motivation, leadership, and organization: Do American theories apply abroad? *Organizational Dynamics, 9*(1), 42–63.

Hogan, J., & Foster, J. (2013). Multifaceted personality predictors of workplace safety performance: More than conscientiousness. *Human Performance, 26*(1), 20–43.

Hollnagel, E. (2011). Prologue: The scope of resilience engineering. In E. Hollnagel, J. Paries, D. D. Woods, & J. Wreathall (Eds.), *Resilience engineering in practice: A guidebook*. Surrey: Ashgate Publishing Limited.

Hollnagel, E., Wears, R. L., & Braithwaite, J. (2015). From safety-I to safety-II: A white paper. The resilient health care net: published simultaneously by the University of Southern Denmark, University of Florida, USA, and Macquarie University, Australia.

*Holte, K. A., & Follo, G. (2018). Making occupational health and safety training relevant for farmers: Evaluation of an introductory course in occupational health and safety in Norway. *Safety Science, 109*, 368–376. https://doi.org/10.1016/j.ssci.2018.05.020.

Huang, J. L., & Bramble, R. J. (2016). Trait, state, and task-contingent conscientiousness: Influence on learning and transfer. *Personality and Individual Differences, 92*, 180–185.

Hutchins, H. M., & Burke, L. A. (2006). Has relapse prevention received a fair shake? A review and implications for future transfer research. *Human Resource Development Review, 5*(1), 8–24.

Hutchins, H. M., Burke, L. A., & Berthelsen, A. M. (2010). A missing link in the transfer problem? Examining how trainers learn about training transfer. *Human Resource Management, 49*(4), 599–618.

*Jeelani, I., Han, K., & Albert, A. (2018). Automating and scaling personalized safety training using eye-tracking data. *Automation in Construction, 93*, 63–77. https://doi.org/10.1016/j.autcon.2018.05.006.

Jokisch, M. R., Schmidt, L. I., Doh, M., Marquard, M., & Wahl, H.-W. (2020). The role of internet self-efficacy, innovativeness and technology avoidance in breadth of internet use: Comparing older technology experts and non-experts. *Computers in Human Behavior, 111*, 106408. https://doi.org/10.1016/j.chb.2020.106408.

Kanfer, R. (1990). Motivation and individual differences in learning: An integration of developmental, differential and cognitive perspectives. *Learning and Individual Differences, 2*(2), 221–239.

Kanfer, R., & Ackerman, P. L. (1989). Motivation and cognitive abilities: An integrative/aptitude-treatment interaction approach to skill acquisition. *Journal of Applied Psychology, 74*(4), 657–690.

Keith, N., & Frese, M. (2008). Effectiveness of error management training: A meta-analysis. *Journal of Applied Psychology, 93*(1), 59–69.

Kim, A., Schweighofer, N., & Finley, J. (2019). Locomotor skill acquisition in virtual reality shows sustained transfer to the real world. *Journal of NeuroEngineering and Rehabilitation, 16*(113). https://doi.org/10.1186/s12984-019-0584-y.

Kluge, A., & Burkolter, D. (2012). "Being prepared for the infrequent": A comparative study of two refresher training approaches and their effects on temporal and adaptive transfer in a process control task. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 56*(1), 2437–2441.

Knowles, M. (1996). Andragogy: An emerging technology for adult learning. London, UK.

*Kovacic, M., & Cunningham, K. (2019). Effective electrical safety program training in multi-lingual/cultural environments. *IEEE Transactions on Industry Applications, 55*(4), 4384–4388.

Kraiger, K., Ford, J. K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of Applied Psychology, 78*(2), 311–328.

Krauss, A. D. (2005). *The transfer problem: Examining the direct and interactive effects of safety training transfer climate and work locus of control on the transfer of safety training* (unpublished thesis). Colorado State University.

Krauss, A., Casey, T. W., & Chen, P. Y. (2014). Making safety training stick. *Contemporary Occupational Health Psychology, 3*, 181–197.

*Liang, Z., Zhou, K., & Gao, K. (2019). Development of virtual reality serious game for underground rock-related hazards safety training. *IEEE Access, 7*, 118639–118649. https://doi.org/10.1109/Access.628763910.1109/ACCESS.2019.2934990.

Lingappa, A. K., Kiran K, K., Oommen Mathew, A., & Wright, L. T. (2020). Safety training transfer in chemical manufacturing: The role of personality traits and learning motivation. *Cogent Business & Management, 7*(1), 1835335. https://doi.org/10.1080/23311975.2020.1835335.

Lingard, H., & Rowlinson, S. (2005). *Occupational health in construction project management*. USA: Spoon Press.

*Loosemore, M., & Malouf, N. (2019). Safety training and positive safety attitude formation in the Australian construction industry. *Safety Science, 113*, 233–243. https://doi.org/10.1016/j.ssci.2018.11.029.

Malakis, S., Kontogiannis, T., & Kirwan, B. (2010). Managing emergencies and abnormal situations in air traffic control (part I): Taskwork strategies. *Applied Ergonomics, 41*(4), 620–627.

Mao, Y., Chen, P., Li, L., & Huang, D. (2014). Virtual reality training improves balance function. *Neutral Regeneration Research, 9*(17), 1628–1634.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review, 20*(3), 709–734.

Murphy, P. K., & Mason, L. (2006). Changing knowledge and beliefs. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (pp. 305–324). Lawrence Erlbaum Associates Publishers.

Namian, M., Albert, A., Zuluaga, C. M., & Behm, M. (2016). Role of safety training: Impact on hazard recognition and safety risk perception. *Journal of Construction and Engineering Management, 142*(12). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001198 04016073.

*Namian, M., Albert, A., Zuluaga, C. M., & Jaselskis, E. J. (2016). Improving hazard-recognition performance and safety training outcomes: Integrating strategies for training transfer. *Journal of Construction and Engineering Management, 142*(10), 04016048. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001160.

Naquin, S. S., & Holton, E. F. III, (2002). The effects of personality, affectivity, and work commitment on motivation to improve work through learning. *Human Resource Development Quarterly, 13*(4), 357–376.

Olenick, J., Blume, B. D., & Ford, J. K. (2020). Advancing training and transfer research through the application of nonlinear dynamics. *European Journal of Work and Organizational Psychology, 29*(4), 541–555.

Payne, S. C., Bergman, M. E., Beus, J. M., Rodríguez, J. M., & Henning, J. B. (2009). Safety climate: Leading or lagging indicator of safety outcomes? *Journal of Loss Prevention in the Process Industries, 22*(6), 735–739.

Rasheed, R. A., Kamsin, A., & Abdullah, N. A. (2020). Challenges in the online component of blended learning: A systematic review. *Computers & Education, 144*, 103701. https://doi.org/10.1016/j.compedu.2019.103701.

Rasmussen, J. (1997). Risk management in a dynamic society: A modelling problem. *Safety Science, 27*(2-3), 183–213.

*Robson, L. S., Stephenson, C. M., Schulte, P. A., Amick, B. C. III., Irvin, E. L., Eggerth, D. E., ... Grubb, P. L. (2012). A systematic review of the effectiveness of occupational health and safety training. *Scandinavian Journal of Work, Environment & Health, 38*(3), 193–208.

Rouillier, J. Z., & Goldstein, I. L. (1993). Determinants of the climate for transfer of training. *Human Resource Development Quarterly, 4*, 377–390.

*Ruttenberg, R., & Rice, C. (2019). Assessing the impact of health and safety training: Increased behavioral change and organizational performance. *American Journal of Industrial Medicine, 62*(11), 986–995. https://doi.org/10.1002/ajim.v62.1110.1002/ajim.23026.

Safe Work Australia. (2018). Model code of practice: Work health and safety consultation, cooperation, and coordination. https://www.safeworkaustralia.gov.au/doc/model-code-practice-work-health-and-safety-consultation-cooperation-and-coordination.

Schein, E. H. (2010). *Organizational culture and leadership*. John Wiley & Sons.

Sitzmann, T., & Weinhardt, J. M. (2018). Training engagement theory: A multilevel perspective on the effectiveness of work-related training. *Journal of Management, 44*(2), 732–756.

Smith, G. (2018). *Paper safe – The triumph of bureaucracy in safety management*. Perth, WA: Wayland Legal Pty Ltd.

Stuart, A. (2014). A blended learning approach to safety training: Student experiences of safe work practices and safety culture. *Safety Science, 62*, 409–417.

Tracey, J. B., Tannenbaum, S. I., & Kavanagh, M. J. (1995). Applying trained skills on the job: The importance of the work environment. *Journal of Applied Psychology, 80*(2), 239–252.

Trout, G. (2016). E-learning and online training. *Professional Safety, 61*(6), 34–36.

Tsai, T.-H., Chang, H.-T., Chen, Y.-J., Chang, Y.-S., & Xia, F. (2017). Determinants of user acceptance of a specific social platform for older adults: An empirical examination of user interface characteristics and behavioral intention. *PloS One, 12*(8), e0180102.

*Vigoroso, L., Caffaro, F., & Cavallo, E. (2020). Occupational safety and visual communication: User-centred design of safety training material for migrant farmworkers in Italy. *Safety Science, 121*, 562–572. https://doi.org/10.1016/j.ssci.2018.10.029.

Wallen, E. S., & Mulloy, K. B. (2006). Computer-based training for safety: Comparing methods with older and younger workers. *Journal of Safety Research, 37*(5), 461–467.

Wang, B., Li, H., Rezgui, Y., Bradley, A., & Ong, H. N. (2014). BIM based virtual environment for fire emergency evacuation. *The Scientific World Journal, 2014*, 1–22.

Yorio, P. L., Edwards, J., & Hoeneveld, D. (2019). Safety culture across cultures. *Safety Science, 120*, 402–410.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident Analysis & Prevention, 42*(5), 1517–1522.

Tristan Casey is an expert in safety leadership and organisational culture, and a member of Griffith University's Safety Science Innovation Lab. With a career in workplace health and safety spanning 12 years, he has consulted nationally and internationally across a diverse range of industries. His passion is translating abstract/theoretical concepts into practical tools that have measurable impact.

Nick Turner, PhD (Sheffield) is Professor and Distinguished Research Chair in Advanced Leadership at the Haskayne School of Business, University of Calgary, Canada. His research focuses on work design, transformational leadership, and occupational health and safety.

Xiaowen Hu is an interdisciplinary, applied safety scientist with a passion for integrating diverse theoretical perspective to bring innovative solution to complex real-world problems. She is currently a Senior Lecturer at Queensland University of Technology and teaches a range of courses related to human resource management.

Kym Bancroft is an experienced HSE Executive with a Masters in Safety Leadership and Organisational Psychology. With close to 20 years' experience in safety, health, wellbeing, and injury management Kym has worked nationally and internationally assisting organisations to achieve safety transformation that is sustainable long term.