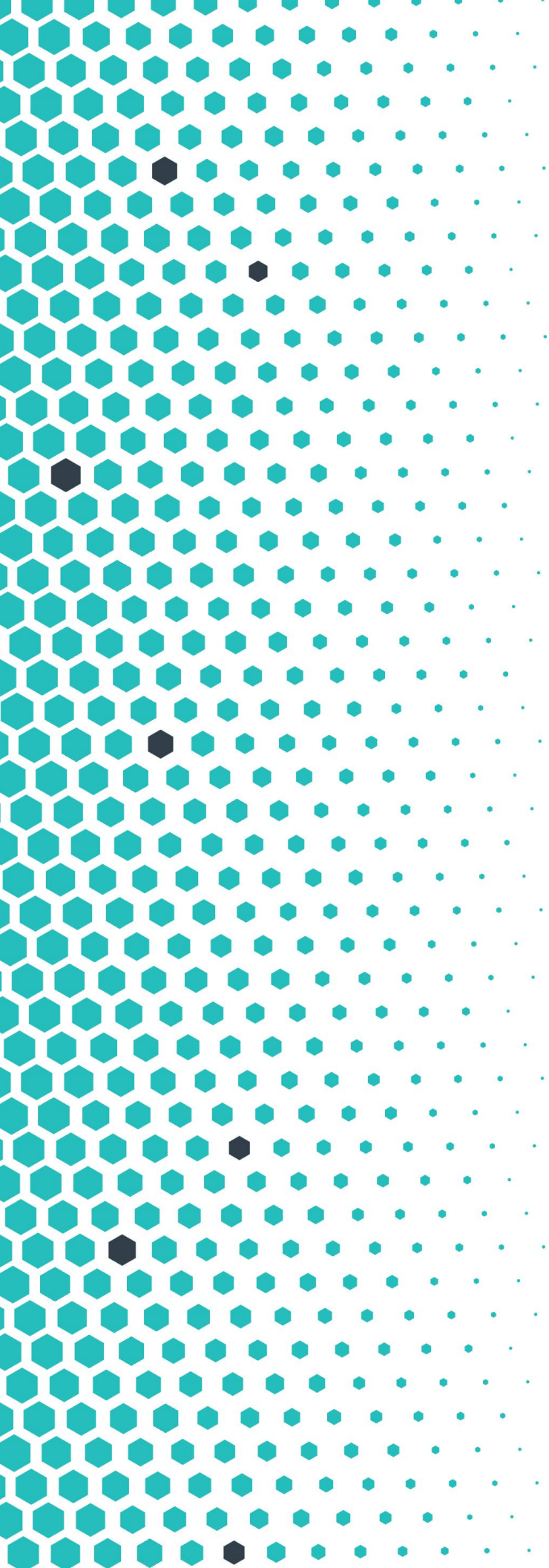

CAMPBELL INSTITUTE™

Campbell Institute Research Outlook

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Technology and Training

Technology has fundamentally changed how businesses operate and work to keep their employees safe. Industry 4.0 leverages technology such as wearables, mobile applications, advanced robotics, machine learning, and artificial intelligence to allow workplaces to run more efficiently and safely. Several areas of technology innovation in the world of environment, health and safety are focused on all aspects of the hierarchy of controls including elimination, substitute, engineering and PPE. However, not as much attention has been paid to technological advancements in how organizations mitigate risk through administrative controls.

For example, companies might invest in drone technology to mitigate work at height risks and substitute the need for humans to do inspection work off the ground. However, that same company might still employ classroom-based training for teaching their workers how to properly use fall protection or climb scaffolding. There are technological advancements in training that organizations can currently leverage to more effectively and, potentially, more easily train their workers. In this literature review, we will summarize recent technological advancements in workplace training including online learning, mobile learning, and virtual reality as well as identify some of the benefits, barriers, and real-time applications of each type of training technology.

E-learning Applications

Organizations often look for ways to improve efficiency, reduce costs, and improve outcomes for their products and services with new and emerging technology. However, focus on improving internal processes for employees sometimes lags behind. For example, many workplaces rely on classroom/lecture style training to administer required training or relay large amounts of information to large groups of employees. With globalization of workforces and the need to relay information across multiple sites and countries, organizations are turning to e-learning and virtual classrooms to provide efficient, on-demand training to their employees, which helps reduce costs associated with typical classroom style training (Rosenberg, 2006).

In general, e-learning refers to everything from web-based training to computer-based module training to social networking applications (Wang, 2018). Not only can e-learning provide alternative means of training employees who are spread across the country or globe (Welsh et al., 2003), but e-learning allows for information to be collectively and centrally stored for organizations to use to monitor learning trends and provide feedback to employees (Harris, 2009). More specifically, e-learning has many benefits that are directly applicable to workplace training including convenience and flexibility, efficiency and cost-savings, adaptability to different learning styles, increased peer interaction, and organizational knowledge management (Wang, 2018).

One benefit of e-learning is the flexibility with which training content can be disseminated and consumed. Employees can access e-learning training with any computer that has an internet connection. Additionally, employees at remote work sites and other non-centralized locations can benefit from just-in-time training without having to commute to classroom or other centralized location to complete training (Short & Greener, 2014). E-learning training can be delivered to many more employees at one time than can classroom-based training. Because the training content is viewable from any internet-accessible computer, workers can revisit trainings to get greater exposure to the training materials than could be offered from a one-time classroom training (Nunes et al., 2009).

Another advantage of e-learning is that training delivered in this setting allows for more self-directed learning on behalf of the employees (Wang, 2018). Because people vary in their preferred learning styles and methods of receiving information, it is important to provide options for learning content that can benefit different types of learning. Self-directed e-learning helps employees go through training content at a pace that works for their learning style, allowing them to repeat modules or sections of content to make sure that they have an understanding of the content. Many people feel anxious in classroom settings and can sometimes feel pressured to go along with the group and not ask questions even if they are having difficulty with the training content (e.g., Hewlin, 2009). Therefore, e-learning helps promote confidence in understanding training materials without employees having to feel embarrassed about asking questions or repeating content.

An early critique of e-learning was that it was too individualized and did not allow for the much needed social interaction among co-workers or between trainer and learner to help solidify new concepts. Recent iterations of e-learning in the form of virtual classrooms and other social online environments have allowed for workers to remotely engage others in learning materials and get feedback and guidance from their peers (Gronseth & Hutchins, 2020). One example of this process uses a 3D virtual environment where employees have to work together to solve problems in real time. In this simulation, each worker has a specific role that is dependent on another worker and they have to figure out how to communicate effectively to solve the problem and complete the proper order of operations between team members to get the job done (Hämäläinen & Oksanen, 2012). This type of task fosters team-building and reinforces new concepts.

Another useful advantage of e-learning is that it enables explicit knowledge management and dissemination across an organizations (Wang, 2018). Knowledge/training for a particular job or set of tasks is often embedded in doing the work itself or embedded in the supervisors and/or workers currently doing that job. Moving to an e-learning platform can help distribute that knowledge to a broader base more efficiently. The experts who know the ins and outs of doing a specific job can relay their knowledge and skills to others through an online medium which helps disseminate knowledge more quickly and also helps organizations keep track of and manage specific expertise in effective ways (Harris, 2009). Therefore, the skills that previously had only seemed transferable on the job, can now be leveraged in ways as to increase formal training efforts and increase consistency in training/learning across an entire organization.

Despite the many advantages of e-learning for workplace training, there are several potential drawbacks to moving training wholly online. Sometimes the e-learning content does not seem relevant to the specific organizational needs or goals (Wang, 2018). Purchasing generic training software that can apply across different organizations is often cheaper but can lead to lower worker engagement with the training as well as more disappointment with the training outcomes (Jones, 2016). It is important for organizations to customize e-learning applications so that they are relevant for the specific contexts in which workers will be using the information learned in the training.

Another area of potential concern with e-learning applications is the context in which organizations administer the training. Companies might implement e-learning trainings without providing any organizational support for dealing with technological issues that are bound to occur. Similarly, management might not provide sufficient time and or resources for employees to complete the e-learning training or understand how completing such training can help advance organizational and professional goals (Nunes et al., 2009). In a similar vein, e-learning programs are sometimes implemented without much thought put into pedagogical outcomes. Organizations might think that

asking someone to watch a series of videos or click through an online demonstration might be enough to fulfill the training requirement. Organizations, however, need to consider methods to pair with the online content that will make the training relevant, engaging, and most of all, effective (Welsh et al., 2003). Most importantly, organizations need to be sure that they are measuring effectiveness of e-learning programs and provide guidance and feedback to employees based on their individual performance.

In addition to the stated benefits of e-learning, many studies have examined whether e-learning actually provides any better learning outcomes than traditional classroom learning. A meta-analysis of over fifty studies found that e-learning and blended classroom (e-learning and classroom learning combined) trainings led to better learning outcomes than standard classroom training (Means et al., 2009). Beyond the actual learning and retention outcomes that are positively associated with e-learning applications, e-learning can increase self-confidence and reduce uncertainty for workers learning new information, partly because learners are able to get more comfortable with the materials and have the freedom to the information at their own pace (Axelson et al., 2007; Leung et al., 2003).

Mobile Learning Applications

Mobile learning involves a similar approach to workplace training as e-learning but specifically utilizes the capabilities of mobile technology to create new methods and avenues for information dissemination. Mobile learning allows learning to take place on the go without the need for an employee to be tied to a computer at a physical location. With mobile phones, tablets, or other portable mobile technology, workers can access information relevant to their specific job while working in the field. There are, however, some more useful and less useful ways to use mobile technology for training purposes.

The initial approach to mobile learning focused on making computer-based training and information available on a smaller, mobile screen. Doing so, however, does not unlock the full potential of mobile technology. Mobile technology training applications can be used as a means of repackaging classroom- or computer-based training for on the go learning, but the real value of mobile technology comes from the ability to create and share content containing real-world examples of information needed on the job in various circumstances. For example, workers can record themselves performing a specific task in the field and share that information to others who might face a similar task in their work environment (Wallace, 2011). Although the ability to record work tasks for training purposes is not new, the connection between the recording ability and instant sharing and communication with others utilizes the unique functionality of mobile technology.

Relatedly, mobile learning has the unique ability to bridge the divide between standard classroom training and on-the-job training. As mentioned earlier, mobile learning applications can deliver typical e-learning trainings formatted to work on a mobile device, so workers can access this information from anywhere that they choose. The benefit, however, comes from being able to combine this just-in-case learning with just-in-time learning when those same workers are actually on the job and are unsure of how to proceed with a specific operation (Pimmer & Pachler, 2014). Oftentimes classroom-based training provides high-level general knowledge of how to perform a certain task or do a certain job. The bulk of experience and knowledge needed to perform the job well and safely usually comes from on-the-job training with supervisors or other experienced coworkers (Harris et al., 2001).

Mobile learning applications can provide that just-in-time type of information for workers when they are unsure about how to perform a job correctly in the field. For example, some employers utilize mobile learning for providing checklists and other job critical information that is accessible from mobile devices. If an employee is in need of operations support and does not have immediate access to a coworker, they can access a list of directly relevant information on their mobile device that provides detailed steps relevant for that specific task. Companies can curate this information and have it available to specific employees without the employee needing to do a Google search for uncurated information (e.g., Ahmad & Orion, 2010).

Mobile learning applications can also help workers connect socially with others and bridge formal and informal learning contexts, which helps to reinforce classroom and in situ learning. For example, some organizations use text messaging and/or other mobile alerts to reinforce classroom-style formal learning in the days and weeks following specific training. The idea here is to take the theoretical knowledge from the formal training and apply that knowledge to specific workplace scenarios for that specific employee (Pimmer & Pachler, 2014). Collecting data from workers in this way also allows organizations to have a real-time measure of the effectiveness of the training and help them see where improvements can be made for connecting formal training to specific work contexts.

Many of the potential barriers for e-learning applications also apply to mobile learning applications. Most relevant to mobile technology, however, is the potential barrier of ease of use and comfortability of the end user/worker. Many in the workforce, especially in industries with an aging workforce, are not as comfortable using mobile technology and can quickly become frustrated using it. Therefore, it is crucial that organizations provide technology-specific training for using the mobile devices and have technical support available to help with troubleshooting as employees encounter technical problems.

Virtual Reality Applications

Virtual reality applications are quickly gaining momentum as tools for training in the workplace. Although virtual reality technology has existed for several decades, the versatility and availability of more user-friendly VR applications has fostered a renewed interest in VR training (Roettgers, 2017). In particular, the ability to have workers enter into virtual environments using head-mounted displays or glasses has opened the door for small- and medium-sized companies to benefit from this technology (Buttussi & Chittaro, 2018). VR applications are particularly useful for hands-on training where workers can get as close to performing the task without actually doing so from the comfort of a classroom or other remote setting. Of course, there are also several potential barriers to fully implementing VR applications for broad training purposes.

In general, virtual reality refers to any computer system that generates simulations of environments with which participants can interact, sometimes using hand-held controllers or other devices (Wilson et al., 1997). From a training perspective, VR applications allow a worker to learn how to do a task as close to as it exists in reality without having to actually do the task or simply learn about doing the task in a classroom setting. VR is particularly useful for risky tasks where a novice worker might be prone to make a mistake without understanding the proper operational procedures (e.g., working on a roof, working with electricity, or flying an airplane).

VR applications leverage the worker's senses to aid in learning how to perform the task. For example, it is difficult to relay in a classroom setting what it feels like to be 30 feet off the ground working on overhead power lines and dealing with the complications and difficulties that exist in working under

those conditions. A VR environment can help workers get the feeling of working at height with dangerous equipment by observing the interaction between their own physical movements and the work environment (Rezazadeh et al., 2011).

In general, there are two commonly used VR applications, immersive VR (using head-mounted displays) and desktop VR (observing VR environment through a computer screen) (Lee & Wong, 2014). Most of the stated potential benefits of VR come from the immersive version of VR training. The immersive nature of this type of VR training also allows workers to experience immediate feedback in a safe and controlled environment without the additional worry of time or cost associated with training in mock-up or real-world environments (Feng et al., 2018). Immersive VR experiences are particularly relevant for safety related training where simulating real-life hazardous scenarios would be too dangerous or impractical to carry out, even in a mocked-up format. In other words, workers can learn how to respond to hazardous situations in a completely risk-free environment (Tichon & Burgess-Limerick, 2011).

Several examples of using immersive virtual reality for workplace training already exist in the literature. VR training has been used for safety training in fire safety (Backlund et al., 2007), pedestrian and traffic safety (Schwebel et al., 2008), hazard recognition (Jorge et al., 2013), construction (Sacks et al., 2013; Wang et al., 2018), and general safety training (Leder et al., 2019). Results on the effectiveness of using VR training compared to conventional training are somewhat mixed. For example, Smith and Salmon (2017) compared immersive VR training to VR training with written instructions and simple photo/video instructions for assembling a small aircraft engine. Performance in time spent assembling and errors made in assembly did not differ among the three groups but participants took longer to go through the instructions in the immersive VR condition.

Therefore, immersive VR training did not necessarily improve performance compared to other options, but it did not worsen performance either. Importantly, participants displayed greater preference for using the VR system compared to other training methods. In other words, the end user experience was much more enjoyable when using immersive VR, which is important to consider for employee engagement and motivation to complete training (Smith & Salmon, 2017). One of the biggest reported benefits of the immersive VR training was that the workers had repeated opportunity to test their knowledge in building the engine assembly and they could try it out several times before they actually had to build it, saving money and time compared to experimenting with a real engine assembly.

These results mirror other studies suggesting that immersive VR training does not improve some learning outcomes compared to traditional workplace training (e.g., Leder et al., 2019). Research by Makransky et al. (2019) suggests that immersive VR training has specific benefits on certain types of outcomes that have not been measured in other studies. They found that people asked to learn a chemical laboratory safety procedure with immersive VR training performed significantly better than those who were trained with a desktop VR simulation or paper-based training but only for behavioral transfer tests, not multiple-choice tests. Therefore, participants who experience the immersive VR training were more likely to put their training into practice in future safety scenarios than those who learned via other methods (Makransky et al., 2019). Consistent with other research, participants in the immersive VR condition were more engaged and reported greater intrinsic motivation, self-efficacy, and overall enjoyment compared to conventional training methods. Therefore, regardless of actual learning outcomes, those who participated in immersive VR training were much more engaged and interested in the training compared to typical methods, a key part of Kirkpatrick's training model (e.g., Kirkpatrick, 1998).

There are potential barriers for virtual reality training, especially when it comes to cost and adaptability to organizational needs. Although VR equipment and software is getting less expensive, investing in VR technology and the programming that is required to have an adequate amount of useful training options can get expensive quickly. Some immersive VR applications are designed for broad applicability across different organizations. Some VR trainings might not be particularly applicable with the specific way that a company operates or might not fit with the organizational goals of that company. Creating custom content, however, is much more time intensive, challenging, and expensive (e.g., Velev & Zlateva, 2017).

Conclusion

Effective training in the workplace, especially in safety sensitive industries has become increasingly important. Many organizations, however, are still using classroom-based training and education without leveraging new technology and digital options for more immersive and engaging training content. New technology like e-learning, mobile learning, and virtual reality applications provide a potential boost to make workplace training more effective, efficient, and less costly. Future research on this topic will outline how Campbell Institute members are utilizing new technology to augment and improve training procedures in their organizations.

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