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The Impact of Technology on Workforce Skill Learning

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The Impact of Technology on Workforce Skill Learning

Thirty years ago, typical workplace training involved a classroom with twenty or so colleagues and one or two instructors, a full day off work to attend the training, and if a person was really lucky, a free lunch. In this training, one might expect to engage in a management role play, to learn about and then practice making a spreadsheet, or to learn about company-specific software for solving a customer problem. The effectiveness of the training would depend on how the training was designed. That is, whether it engaged workers, how the trainers adapted their instruction to the unique needs of each of the learners, and if it provided the opportunity to practice trained skills. After training, some workers would start using the skills learned in training even though – at first – tasks might take longer and performance might be more error prone. Others would revert to their old ways and without practice, the knowledge gained in training would diminish over time.

Today a lot about this scenario as changed, but essential elements remain the same. The best training is still engaging, adaptive, and permits practice. Also, workers still need opportunities to engage in trained skills while back at work to retain what they learned in training. What has changed, however, is how training is delivered. Just as advances in digital technology have significantly disrupted the delivery of education over the past thirty years (Committee on How People Learn II, 2018), the advent of digital technology has significantly changed how employees are trained. Training today is more likely to engage learners through technology – web-based courses, serious games, or micro-learning experiences delivered through their mobile devices – than it was thirty years ago. Today's workers are also expected to take more control of their own learning experiences, from deciding what skills they want to develop to how they want to engage in the training. In other words, workers know that they need to engage in constant skill updating to remain employable now and in the future, just as organizations know they need to invest in the development of their workforce to attract talent and remain competitive (Cascio, 2019).

Although instructor-led classroom training remains the most common type of training in organizations – i.e., accounting for 54% of training hours compared to 23.3% for e-learning - the use of e-learning is continuing to grow and the number of total training hours devoted to e-learning is expected to double by 2022 (ATD Research, 2018). Importantly, these statistics relative to training hours reflect time in formal training environments only, and do not include

informal experiences like learning on the job or self-directed learning outside of corporate training. Including informal learning experiences would likely dramatically increase estimates of the use of digital technology in training and development. It is less clear, however, how the proliferation of technology in workplace training has impacted workplace learning and how it will continue to do so in the coming decades. This Thinking Forward Series paper examines technology and workforce skill learning, going beyond academic research to describe how technology is impacting training delivery and effectiveness in the 21st century.

Training and Technology

Training is generally thought of as a systematic process initiated by an organization with the goal of affecting relatively permanent changes in worker knowledge, skills, or abilities. E-learning is a catchall phrase used by most researchers to describe a broad range of training techniques that engage technology to promote learning (Brown, Charlier, & Pierotti, 2012). The general benefits of e-learning are that it can reduce the cost of training delivery (although it can increase the cost of training development), it can easily accommodate interactive and simulated activities into a training curriculum (which might be particularly useful for skills that are dangerous or associated with rare events), and it can monitor student progress with unobtrusive observation.

The past 30 years has seen a proliferation of the use of technology in training environments, and typically most research studies on technology and learning show a small advantage of e-learning over classroom environments. Importantly, the size of these effects depends on how the training is designed (Means, Toyama, Murphy, Bakia, & Jones, 2009). Although the focus of the current paper is technology in training, not training design, it is important to note that technology per se is not the most important factor in training success. Rather, it is the pedagogy behind the technology that matters. Introducing the best technology into a poorly designed training curriculum will make the training more expensive but will not necessarily make it more effective. Indeed, technology can actually make training worse, particularly when it is not central to the content being trained and distracts learners. The bottom line is that terrible training can be delivered through an interactive digital platform; great training can be delivered by an instructor in a classroom (Bell, Tannenbaum, Ford, Noe, & Kraiger, 2017).

How might instructional designers incorporate technology into training to benefit learners? The best approach would be to match the needs of the training environment with the affordances of available technology. Technological affordances refer to the activities that are facilitated by technology (e.g., interactive activities, content that adapts to the learner's actions, unbiased and immediate feedback; Committee on How People Learn II, 2018). Here we describe technological affordances most relevant to education and training, but in general, instructor-facilitated training can have the same affordances as digitally-delivered training (e.g., it can be interactive, adaptive, and provide feedback). Technological affordances are important because they are scalable in ways that instructor-associated affordances are not. For example, an adaptive web-based training module can be deployed to thousands of learners simultaneously; a single instructor might take years to reach that many learners. Key affordances identified in the context of educational technology are provided below (Committee on How People Learn II, 2018):

- **Interactivity**: when the system presents new information to learners in response to actions initiated by the learner. For example, after a trainee passes a learning check, he is introduced to the next unit of content to be learned.
- **Adaptivity**: when the system presents information contingent on learner characteristics (i.e., knowledge, skills, and abilities). For example, the training content presented to the learner through an online learning management system is customized to the learner's specific knowledge gaps.
- **Feedback**: system-driven feedback is generally immediate and unbiased if errors are captured by the system.[1] For instance, the practice module of interactive training can immediately tell a customer service trainee that she has clicked on the wrong link during the training session.
- **Learner control**: technology can provide learners choices about what, and how, to learn so learners can regulate their own learning. For example, one trainee may choose to complete more than the required practice exercises while learning a spreadsheet program; another may choose to complete very little practice because she has extensive experience with the material.

[1] In this context, unbiased feedback means that the same feedback is provided to all learners who make the same mistake. When data are collected via artificial intelligence, however, the feedback itself may be biased by the types of behavior that comprise the system's "knowledge" base.

- **Nonlinear access**: technology permits increased flexibility in accessing training content. For example, a project manager can choose to brush up on her Gantt chart skills by choosing to review only the Gantt chart module in a Massive Open Online Course on project management.
- **Linked representations**: technology permits relatively easy links to relevant content to emphasize different viewpoints, to suggest related media, to provide definitions and concrete examples, and so on. For instance, a web-based training module on corporate ethics can provide hyperlinks to external sources that review seminal legal decisions.
- **Open-ended learner input**: technology permits learners to engage and respond to the system in open-ended ways. For instance, learners can upload documents and provide responses to inquiries that lead to deeper processing of information than is possible through simple rote memorization.
- **Communication**: Technology facilitates communication with other people engaged in the learning experience. Communication can be asynchronous or synchronous, and can take many forms (text, audio, video). For instance, a group of eight specialized workers in remote locations and one trainer can participate in a web-based training to learn a new tool. Trainees can share best practices with each other and with the trainer.

In addition to these affordances, technology can impact the timing, location, pacing, and formality of training delivery (Committee on How People Learn II, 2018). Timing can be synchronous, as when trainees and trainers engage in training simultaneously (e.g., a live webinar) or asynchronous, as when trainees and trainers engage in training at different times (e.g., a Massive Open Online Course, MOOC). Whether synchronous or asynchronous, e-learning generally provides local or remote access of training content. Pacing refers to whether the training is instructor-paced or self-paced. Self-paced training is more common in digital platforms where learners typically have more control over their own training experiences (e.g., they can usually navigate through e-learning programs at their leisure and go back and review information when necessary). The formality of training typically refers to whether the training is systematic and includes activities such as attending class, taking notes, and so on. Informal learning, by contrast, is defined as unstructured, experiential learning that could include on-the-

job training such as asking for help to solve a specific problem or observing others to learn a new skill (Tannenbaum, Beard, McNall, & Salas, 2010).

The State of the Art in E-Learning

Any discussion of e-learning innovations will be outdated by the time it is published. Nonetheless, describing the state of the science and practice of training technology – and what we know and don't know about the effectiveness of these techniques as of early 2019 – will, at minimum, provide a snapshot of the state of the field that can later be examined like a time capsule in the context of as of yet unforeseen technological innovation. A summary and brief description of prevalent e-learning approaches as of 2019 is shown in Table 1 and these descriptions are elaborated below the table. I have also linked these e-learning approaches to the technological affordances and delivery characteristics described above (although the extent to which each e-learning strategy has these characteristics will, of course, depend on its design). Notably, the e-learning approaches listed are neither independent (i.e., conversational agents are arguably a type of intelligent tutor, micro-learning experiences can be deployed using artificial intelligence, blended learning can employ virtual reality) nor exhaustive. The list was developed through a perusal of the academic literature on education technology and organizational training, practitioner resources such as the Association for Talent Development State of the Industry Report (ATD Research, 2018), and an array of popular press articles about innovations in corporate training.

Table 1. *Brief Descriptions of E-learning Types Linked to Key Affordances and Delivery Attributes*

E-Learning	Description	Key Affordances and Delivery Attributes
Web-based Instruction	Instruction delivered via the World-Wide Web	Remote access Asynchronous Self-paced Formal Interactive Feedback Learner control Non-linear access Linked representations Open-ended learner input Communication
Blended Learning	Integrating classroom/face-to-face learning with web-based or computer-based instruction	Formal Interactive Adaptive Feedback Linked representations Open-ended learner input Communication
Massive Open Online Courses (MOOCs)	Online courses that are generally free to any student. Typically include video instruction, some interactive instruction, and assignments.	Remote access Asynchronous Self-paced Formal Interactive Feedback Learner control Non-linear access Linked representations Open-ended learner input Communication
Gamification	Use of immersive narratives to engage learners in decision making	Remote access Asynchronous Self-paced Interactive Adaptive Feedback Communication

E-Learning	Description	Key Affordances and Delivery Attributes
Virtual Reality	A model of reality that is presented through the use of hardware and software	Self-paced Formal Interactive Adaptive Feedback
Augmented Reality	The superimposing of information on the real environment through the use of hardware and software	Self-paced Formal Interactive Adaptive Feedback
Intelligent Tutoring	Diagnoses learning problems and provides feedback to the learner	Remote access Asynchronous Interactive Adaptive Feedback Communication
Conversational Agents and Chatbots	An intelligent agent that simulates text to engage, prompt, and provide feedback to the learner	Remote access Asynchronous Interactive Adaptive Feedback Communication
Micro-learning	Short engagement in interactive tools that is presented in real time.	Remote access Asynchronous Interactive Adaptive Feedback Learner control Non-linear access
Mobile Learning	Training delivery using mobile devices (cellphones and tables) that allows on-demand access to instructional resources.	Remote access Asynchronous Interactive Adaptive Feedback Learner control Non-linear access Communication

Web-based instruction and blended learning.

Web-based instruction is defined as using the Internet to deliver instructional material. Although functionality varies depending on the quality of the program (it can range from ad hoc

YouTube videos to a full blown 15-week course), most web-based instruction is capable of remote and asynchronous delivery of training content. High-quality web-based instruction can also engage interactivity, feedback, learner control, non-linear access, linked representations, open-ended learner input, and communication with other learners through course forums. A meta-analysis comparing classroom to web-based instruction found that web-based instruction was more effective at teaching declarative knowledge but not more effective than classroom instruction for teaching procedural knowledge (Sitzmann, Kraiger, Stewart, & Wisher, 2006). The Sitzmann et al. study also found that the effectiveness of web-based instruction was augmented compared to classroom instruction when the instruction included learner control, permitted interactive practice, and provided feedback. Conversely, when the web-based instruction was designed without these affordances to look exactly like classroom instruction (e.g., it simply took class Power Point lectures and transferred them to course websites), the advantage for web-based over classroom-based training disappeared.

Means et al. (2009) conducted a meta-analysis examining the effectiveness of web-based instruction in educational contexts. They reviewed over a thousand articles for potential inclusion in the meta-analysis and found relatively few study effects (fifty-one) that represented rigorous enough research to be included (i.e., studies that included a treatment and control group). Results of the Means et al. meta-analysis suggested a learning advantage for web-based versus face-to-face instruction in K-12 contexts and an even greater advantage for blended approaches. Blended learning is simply a mix of web-based and classroom-based methods. For instance, an instructor might facilitate group discussion during class time but expect students to log on to the course website to watch lectures and take quizzes as homework. Means et al. note, however, that students in the blended learning condition also spent more time with the training content. As such, it may be time - not the online component - driving the positive effect for blended learning approaches. In summary, research suggests that web-based and blended approaches are generally effective, and can be more effective than classroom learning providing that they capitalize on technological affordances.

Massive Open Online Courses (MOOCs).

MOOCs are web-based courses delivered through one of many service providers (e.g., Coursera, EdX) to the general public at very low or no cost to learners. When originally introduced about a decade ago the promise of MOOCs was their potential to democratize education by providing world-class instruction no matter a student's resources or background (indeed many original MOOCs were provided by instructors at Harvard and MIT). All a student needed was an internet connection and time – usually a few hours a week over a 15-week semester – to participate in a MOOC. Over the past decade it has become clear that the promise of MOOCs has not been realized. Rather than democratizing education by reaching those most economically disadvantaged, the majority of MOOC students are in the richest countries around the world. Attrition rates for MOOCs are also painfully high. Students tend to register for MOOCs and not participate in them, or students disengage after a few sessions due to time constraints or loss of interest. Perhaps most distressing however, is that students who engage in MOOCs one time tend not to repeat the experience, which suggests that students don't generally perceive the experience as valuable (Reich & Rulperez-Valiente, 2019). Because of these issues, many MOOC providers have shifted their business models from providing content to the masses free of charge to providing online, web-based content to instructors to supplement classroom instruction. Many have also moved toward providing fee-based professional training such as certification and professional master's degrees through universities given the demand for such experiences: 44% of students enrolled in MOOCs report engaging in the courses to enhance their work-related skills (Christensen et al., 2013).

Research on MOOC effectiveness is difficult given that there is not an apparent in-person classroom equivalent to serve as a control (i.e., no free semester-long university courses open to the general public with which to compare performance). Moreover, the validity of MOOC research on learning is threatened by selection bias given that people who sign up for MOOCs are interested enough in the topic of study, and in learning more generally, to devote time and energy to such a course. However, given that MOOCs are essentially the same as web-based instruction, there is every reason to believe that MOOCs can be effective instructional methods, provided they take advantage of affordances such interactivity, feedback, learner control, nonlinear access, linked representations, open-ended learner input, and communication.

One area in which the study of MOOCs has expanded our understanding of e-learning is in the study of *how* people engage in learning environments. Due to the large number of people who participate in MOOCs, and their online nature, MOOCs provide data about learner behavior, particularly as related to the importance of communication with other learners and instructors through course forums. Course forums provide learners the ability to ask questions, to endorse certain responses as correct, to learn from others, and to observe others' comments and stories. Research suggests that communication with other learners and instructors through course forums is an indicator of retention and grades in MOOCs (Almatrafi & Johri, 2018). Although researchers know very little about the importance of social interaction in training, these findings highlight the importance of examining the social context of training regardless of context (classroom or online). It is unclear, for instance, whether interacting with fellow students and instructors in classrooms (where other learners are present) versus digital platforms (where the learner is likely to be alone and interacting online) will affect learning.

Gamification.

Gamification refers to the use of simulation games to deliver educational content by providing an immersive and interactive environment that engages learners in a narrative story. While immersed in these environments, learners are able to make decisions and learn from the outcomes of those decisions. Games have been used in educational contexts throughout modern history, and serious computerized games have likewise been around for decades (e.g., *Oregon Trail*, produced by the Minnesota Educational Computing Consortium in 1971). Good gamification can engage affordances such as interactivity, adaptive responses, immediate and unbiased feedback, and communication with other learners if the game is multi-player.

A meta-analysis on the effectiveness of simulation games in training suggests that they are indeed effective for teaching declarative knowledge and procedural skills relative to non-gamified content (Sitzmann, 2011). However, researchers warn about publication bias in serious game research because of the difficulty of finding equivalent control groups (Sitzmann, 2011). Moreover, research suggests that when classroom activities are themselves designed to be immersive and engaging, the advantage of serious games is eliminated.

A more recent concern about the rollout of training gamification has been raised by the Society of Human Resource Management (SHRM; Lewis, 2019). Although somewhat anecdotal given the sparse research in this area, a case study examining the use of an electronic leaderboard

to track and incentivize performance suggests that workers may not appreciate the broadcasting of their daily performance relative to their colleagues. In a training context, gamification may promote competition and normative comparisons that can engage the wrong mindset for training; that is, competition can induce a performance mindset where learners focus on *demonstrating* competence relative to others versus a learning mindset where learners focus on *developing* competence. Although SHRM suggests that many organizations are starting to use games in their training portfolios (Lewis, 2019), there is currently little research on the use of games for training in corporate environments, making this another area ripe for future research.

Virtual reality.

Virtual reality involves immersing a learner in a media-rich context that replicates a real-life environment. Learners engage in virtual reality training using specialized equipment (headsets) that provide a 360-degree three-dimensional perspective of the kinds of environments they might encounter in real life. Depending on how the training is designed, learners may be able to manipulate objects they encounter in these virtual worlds. Virtual reality training thus provides an interactive environment that adapts to learners' actions and provides feedback. Virtual reality training has been used extensively to train professionals in rare and dangerous environments, and it is used when the cost of making a mistake is particularly prohibitive. For instance, virtual reality has been used to train medical professionals (e.g., surgeons), astronauts, pilots, and drivers. Research shows that this training is effective (Ford & Meyer, 2014), although it can be expensive and difficult to develop.

Augmented reality.

Virtual reality transports a learner to a completely virtual world. By contrast, augmented reality overlays virtual objects onto the physical world. As such, it creates a learning environment that combines features of real and virtual environments. Augmented reality is usually deployed through mobile devices (tablets and smartphones) or head mounted displays and it provides an interactive environment that adapts to the learners' actions and provides feedback. Pokémon Go (Pokémon corporation and Niantic) is perhaps the most well-known example of augmented reality, where users search for Pokémon characters that are inserted into the real world via a mobile phone application. The explosive popularity of this game demonstrates the potential for augmented reality to engage learners. Its advantage over virtual

reality is its flexibility of implementation and its potential to be deployed without specialized equipment.

Augmented reality displays have been used to teach geographic information about the earth and the composition of different cities, provide students simulated experiences with the solar system and the universe, and to teach anatomy (Saidin, Abd Halim, & Yahaya, 2015). Most of these applications use augmented reality to supplement instruction, not to replace it. Student reactions to augmented reality applications are generally positive, but research is needed to assess the efficacy of augmented reality for learning, particularly in professional settings.

In organizational contexts, augmented reality is thought to have the most potential to change the way that medical training is delivered (Wiederhold, 2017). For instance, augmented reality can overlay realistic graphic models of procedures being discussed in lectures or training modules. Medical professionals can also practice skills when graphics are overlaid on medical manikins (e.g., to practice high risk procedures such as intubation and surgery). The ability to practice and learn high-risk medical procedures might be particularly important for rural medical professionals living in relatively small communities due to their limited ability to otherwise practice such skills. Although the jury is still out on the effectiveness of augmented reality training techniques, the availability of augmented reality is expected to increase in the next few years and to outpace the use of virtual reality for medical training (Wiederhold, 2017). Augmented reality has not been as widely adopted outside of medical communities, but it has the potential to engage learners and should be considered as an e-learning option, particularly when the performance context is important and the skills to be learned are rare and/or high risk.

Intelligent tutoring.

Relatively straightforward computer tutoring systems have been engaged in educational contexts since the 1960s, but these systems were generally not interactive nor were they adapted to the unique needs of learners. The second generation of computer-assisted tutoring, intelligent tutoring systems, guides learners through problems, creates hints, and provides immediate feedback from expert-generated databases. Intelligent tutors tend to be interactive and adaptive to learner behavior and they can take many forms such as text-based or conversational agents. One might imagine, for instance, an intelligent tutor embedded in a website or a mobile application that provides learning checks and directs trainees to relevant content to fill identified learning gaps. A meta-analysis on the effectiveness of intelligent tutors suggests that they are

indeed effective in educational environments, raising student test scores about two-thirds of a standard deviation on average (Kulik & Fletcher, 2016).

Conversational agents and chatbots.

Like intelligent tutors, intelligent conversational agents interact with learners, adapt to learner actions, and provide immediate feedback to learners on the problems they are tackling in training. Conversational agents have been used in educational settings to allow students to engage with experts as students navigate difficult course material online. A single conversational agent can act as an expert or as a peer learner. Depending on the content to be trained, multiple conversational agents can be used to model social interactions, to serve as experts or peer learners, or to engage in arguments that might be informative to a learner. Conversational agents have been deployed in the context of educational games, which might also include virtual reality or augmented reality. The advantage of conversational agents is that they can be programmed to combine the benefits of encyclopedic topical expertise and pedagogical skills. Empirical studies support the effectiveness of intelligent tutors compared to trained human tutors showing medium to large effects for test performance (average d = .8; Graesser, Li, & Forsyth, 2014).

Conversational agents have been used in industry to assist consumers in completing complex activities online such as booking a trip, investigating insurance benefits, or engaging in any non-standard interaction like disputing a charge or attempting to return an item purchased online. These agents are designed for relatively short duration interactions and are called "chatbots" by some (Han, 2017). Although they have not yet been used extensively in training and development contexts, they have the potential to provide interactive and adaptive content and immediate feedback. Many chatbots also allow open-ended input in the form of questions asked of the system (although the translation software is not perfect).

With the increasing popularity and sophistication of technology like Siri and Alexa, the use of chatbots for training and development is not too far into the future. Although there is no research to support the use of chatbots in organizational training, SHRM recently described how conversational agents might be deployed in corporate training environments (Han, 2017). For example, chatbots could provide support for training transfer by reminding learners about best practices learned during training. Chatbots could ask questions about material learned in training to identify gaps in learning, suggest supplemental training material, and they could assess training transfer by asking trainees if they are using learned skills back on the job. In addition to

these functions, one might imagine that chatbots could be used to facilitate the delivery of micro-learning modules, described below.

Micro-learning.

Micro-learning modules are short, digital lessons that provide opportunities to practice skills anytime and anywhere. Although micro-learning can be delivered through any device, it is usually delivered through mobile devices, replacing mindless scrolling with productive mini-training sessions. Depending on how micro-learning modules are developed, they can be interactive, adaptive, provide feedback, and they can be used whenever and where ever the learner wants. They are currently being offered through e-learning companies (Udemy, Lynda.com – connected with LinkedIn) on an array of technical and interpersonal corporate skills. Current micro-learning modules tend to include videos followed-up by interactive exercises and they generally take about 5 minutes (with a quiz) to complete. Theoretically, these short training activities support learning by providing the opportunity to practice at spaced intervals and to receive immediate feedback. Although they are generating excitement among scientists and practitioners (Cascio, 2019), research on the effectiveness of micro-learning modules is sorely lacking at present.

Mobile Learning.

Mobile learning has been defined as the delivery of training content using technological tools that allow learners on-demand access to instructional resources using mobile devices (Wasserman & Fisher, 2018). Mobile learning arguably represents a mode of delivery more than a type of e-learning, but its prevalence and role in innovation in training and development delivery warrant special consideration here. In 2017, LinkedIn Learning Solutions reported that 40% of all job candidates apply for jobs on smartphones and 67% of people reported that they use mobile devices for organizationally-relevant learning (Cascio, 2019) even though only 2% of organizations indicated that they delivered training via mobile devices (ATD Research, 2018). These trends suggest that even when web-based learning is not specifically designed for mobile devices, people use their devices to engage with it.

Although mobile training does not inherently represent any of the technological affordances described above (i.e., it only adds flexibility to the location of training delivery), mobile learning platforms represent a delivery mechanism for many of the exciting innovations in e-learning, particularly as related to timing, context, and social interaction. Specifically,

portable internet-enabled devices permit access to virtually any of the e-learning approaches described in Table 1 from anywhere at any time. Although the small size of mobile devices, particularly cellphones, may be problematic depending on the design of the training module, mobile devices may be particularly useful for micro-learning sessions. GPS sensors that are part of mobile devices can also provide context to the learning environment. One might imagine, for instance, an augmented reality scenario that integrates intelligent agents or a training scenario with a trainee's actual location (e.g., similar to Pokémon Go). Although they are not inherently social, mobile learning devices tend to be used to engage with social media, which might also be exploited in the development of learning technology. For example, the crowdsourcing of feedback and of best practices may prove useful in organizational training. Mobile devices can also provide convenient access to learning forums such as blogs and course-specific chat rooms. Mobile devices also provide an interesting shift in thinking about who actually owns training hardware. That is, individual workers tend to bring their own devices (BYOD; Wasserman & Fisher, 2018) into the mobile learning context, a factor that may complicate the development of mobile learning experiences given that they will need to be designed to operate on an array of platforms. The BYOD approach also raises potential security concerns depending on the sensitivity of the training content.

Another potential downside of mobile learning is that mobile devices inherently promote multi-tasking behavior. Divided attention and distraction are notoriously bad for learning and because of this, mobile devices may not be the best mode of delivery for training content, particularly if the training is relatively long in duration. Despite the concerns associated with using mobile devices for delivering training content, it is likely that people will continue to use them to engage in training content regardless of how the training is designed. To date there is very little research on the effectiveness of mobile learning approaches, however.

Abiding Questions and Research Opportunities

It is exciting to think about technology's potential to enhance training and development in organizations. And yet, many attempts to incorporate technology into organizational training are lackluster or fail, and some organizations have been slow to adopt e-learning approaches. What are some of the factors that contribute to successful e-learning? What are the considerations for organizations in implementing these approaches?

Fantasy versus reality.

In researching the different approaches to e-learning for this paper, it became increasingly clear that there was a chasm between what can be done (e.g., interactive and adaptive training that relies on machine learning and artificial intelligence to provide individualized training experiences of appropriate lengths to learners via augmented reality wherever they are in the world) and what is generally done (e.g., classroom training using videos of PowerPoint presentations and CD-ROMS). If so much technological innovation is out there, and if companies can retain talent by offering state-of-the-art training and development programs (Cascio, 2019), why aren't more organizations innovating in their training programs? Certainly the cost of digital training technology is part of the issue, and many organizations may choose to wait to learn from the mistakes of early adopters. This isn't a bad strategy. Avoiding expensive missteps may not be a problem for well-resourced tech companies, but for most organizations training and development is a support function, not part of the technical core. Looking forward, because of the expense and specialized skill associated with the development of digital training content, it is likely that innovations in e-learning will be designed and developed by specialized technical companies rather than in-house for most organizations. The outsourcing of e-learning represents a shift in the business model for many organizations and its implications should be studied in the years to come.

Even if organizations have the resources to invest in the development of technologically sophisticated e-learning, another limitation is the amount of data required to implement truly interactive and adaptive training technology. The artificial intelligence needed to develop truly adaptive training requires mountains of data on human behavior and advanced techniques for data analysis. It is one thing to develop these programs in educational environments where literally thousands of students learn and are tested on the same material every year. It is quite another to develop them in organizations where relatively few people are trained in any one job. Looking forward, it may be useful to deploy adaptive training for general skills that cut across jobs (e.g., interpersonal skills, project management, surgical or engineering skills) rather than specialized job skills or equipment. As of this writing, however, the development of highly adaptive and interactive training approaches that integrate artificial intelligence in organizations is more talk than reality. Moreover, systematic biases that are built into artificial intelligence programs that affect what these systems respond to (e.g., responding differently to people of

different genders, races, or ages) need to be seriously considered in the context of training. We may still be decades away from capitalizing on the promise of machine learning and artificial intelligence in organizational training and development.

E-learning attitudes.

One underlying assumption about e-learning is that it will be universally accepted by learners – indeed that learners will be eager to embrace new technology to support their learning. Although it is true that e-learning programs that are well designed and that prove valuable for learners will likely be accepted by users, there remain barriers to adoption of e-learning for many workers and organizations. First, many learners may prefer the social components of in-person classroom training that are hard to replicate in e-learning. Great human instructors generate enthusiasm for the training content and can adapt to the individual needs of learners much more efficiently than any e-learning approach, and trainees effectively learn by watching their neighbors in training. In-class training also provides valuable networking opportunities for employees who can get to know people who have similar jobs across the organization (or even within their units). Moreover, in-class training tends to provide employees with time away from their daily work to engage in training, signaling to employees that the organization values their development enough to sacrifice work time. Because e-learning can be done at anytime or anyplace, employees may perceive that they should engage in training outside of normal work hours, which signals that the organization does not care about employee development or wellbeing. Ideas to mitigate potential negative responses to e-learning include: combining e-learning with classroom training (i.e., blended learning), providing space away from the office where people can engage in e-learning with other learners (e.g., a digital learning café or library), and/or clearly communicating the expectation that e-learning courses can be completed during work hours.

E-learning and informal training.

Training practitioners have described a blurring of the line between formal and informal training as a function of technology (Horne, 2018). For example, imagine an intelligent agent embedded in a spreadsheet software program alerts an accountant that he could better accomplish his task using pivot tables and offers a training module to provide pivot table training. Because the training module leads him through a series of lessons, one might argue that the training is formal and structured. However, to the extent that the accountant has engaged an

ad hoc learning experience on the job, he is engaged in informal training and development on his own.[2]

The ease with which asynchronous technological training can be deployed promises to increase the quality and the consistency of the information provided in informal learning activities. Another, more extensive and hypothetical example illustrates this point. Imagine a manager wanted to brush up on performance management skills to prepare for performance reviews the next day. She might role play a performance review with an intelligent agent who identifies her strengths and weaknesses and then recommends the manager engage with an organization-specific online training module designed to meet her needs. In this example, the initial skills assessment via intelligent agent and the targeting of skills makes training potentially more efficient. The use of a training module developed in-house provides her relevant content delivered just in time to be useful to her.

The second way technology will impact informal learning is that it can support the measurement of training outcomes. To date, there has been little research on informal learning, perhaps because it is extremely difficult to study unpredictable and individual events in any systematic way. The same technology that is used to provide informal learning experiences might also be used to assess the effectiveness of these experiences, however, making the assessment of learning in informal environments possible. For instance, the spreadsheet program used by the accountant in the example above might be programmed to collect data on whether the intervention with the intelligent agent was effective (i.e., whether the accountant was able to successfully make a pivot table) and it might also assess whether the accountant uses the pivot table function effectively in the months to come (i.e., far transfer). Although this approach is exciting in that it could permit an objective assessment of informal training effectiveness and lead to improvements in learning outcomes, it also highlights issues of big data and machine

[2] Incidentally, the type of intelligent agent described in the scenario above is reminiscent of Microsoft's Clippy, who was introduced in 1998. Clippy was an interactive paperclip animation that appeared on the screen when a user was engaging in a task (e.g., writing a letter, conducting a mail merge) to provide assistance. Clippy was loved by some but reviled by many. One problem was that, although it was interactive and somewhat adaptive to the actions of the user, Clippy was mainly designed with first time users in mind. This meant that the advice Clippy provided was not as valuable for experienced learners who, over time, found Clippy to be tedious and bothersome. Clippy met its end 2007. Hopefully, adaptive training technologies of the future will be able to adapt to skills at all levels to avoid Clippy's fate (Cain, 2017).

learning related to worker privacy and autonomy. Furthermore, increasing reliance on artificial intelligence to decide what training to give which employees may perpetuate implicit biases that are becoming codified in artificial intelligence algorithms (Caliskan, Bryson, & Narayanan, 2017). Employee privacy concerns and biases associated with artificial intelligence need to be considered in the development of any organizational program using artificial intelligence and training and development programs are no exception.

The future of work and the future of the workforce.

Inherent difficulties associated with developing e-learning technology are that, by the time the training is ready to be used, it might be out of date, the training platform might be obsolete, and/or the trained task may no longer be part of the job. It is difficult enough to design training for current jobs. It is even harder to design training for jobs that don't yet exist. Although it is impossible to predict with certainty what jobs will emerge in the future, organizational scientists do know that the shift from manufacturing jobs to knowledge and healthcare jobs that began in the 20th century will continue into the foreseeable future. Jobs that are not completely replaced by automation will change through the outsourcing of simple and rote tasks to machines; a change that will shift the focus of remaining jobs to complex technical and interpersonal skills. Two important questions to address these changes are: What are the most effective approaches for training complex technical and interpersonal skills? What are the most relevant technological affordances associated with these e-learning approaches (e.g., interactivity, adaptivity, feedback, communication)?

In addition to the evolution of the types of jobs available, the workforce is also rapidly changing. Demographic shifts in worker age are expected across industrialized countries in the coming decades; shifts that are influenced by extended lifespans, reduced birthrates, and in the U.S., the financial needs of retirees who have not adequately saved for retirement. Moreover, jobs are likely to constantly evolve with the proliferation of technology in ways that will require workers of all ages to continually update their skills to remain employable. The advantage of an older workforce is that older workers are likely to possess extensive knowledge and experience. But these advantages are balanced by increased difficulty learning novel information with age (Beier, Teachout, & Cox, 2012). Older workers also have lower self-efficacy for learning than do younger workers, particularly for technology-related training, even though research suggests that they can learn just as much as younger workers if training is well-designed and personalized (i.e.,

self-paced, adaptive, with appropriate structure and feedback). Luckily, personalized learning is well-aligned to the technological affordances described above, particularly as related to adaptive and self-paced training.

Interpersonal skills training.

Although organizations continue to increase the amount of e-learning they deliver, it may be surprising that in 2017, traditional instructor-led classroom training was the delivery mechanism that accounted for the most training hours according to a recent survey by the Association for Talent Development (54%; ATD Research, 2018). Although the ubiquity of e-learning is expected to increase over the coming decades – i.e., the number of organizations where e-learning comprises the majority of their training portfolio is expected to double in the next five years – the popularity of classroom training shows no sign of abating. Some of the popularity of person-led classroom training may be because training on communication and managerial/supervisor skills (i.e., interpersonal skills training) is increasing in popularity, and this type of training tends to be done in classroom environments (ATD Research, 2018).

We are likely decades away from a computer algorithm that can understand effective interpersonal behavior and provide trainees appropriate feedback across myriad situations. Although we tend to think of interpersonal skills training as heavily reliant on human instructors, there are technological affordances that have the potential to augment or replace current approaches. For example, borrowing from social media, technology might be used to crowdsource feedback on video snippets of interpersonal behavior (e.g., delivering a performance review in a role play, a sales interview, a presentation). Crowdsourced reactions may be more accurate than those obtained from a single instructor because they would represent reactions from many people and thus would not be biased by one individual's opinion. Drawbacks of this approach, however, are that societal biases will likely be reflective in crowdsourced feedback, and that un-curated feedback may be unproductive or even destructive if it is mean spirited. In summary, technology permits potentially interesting avenues for the development of interpersonal skills, this potential needs to be balanced with the potential drawbacks of bias and the destructive impact if left un-curated.

A Research Agenda and Note about Future Research

Although the e-learning industry is burgeoning with new possibilities for integrating technology into training and development activities, research on the effectiveness of e-learning

approaches is woefully lacking (Cascio, 2019). Indeed, over the last decade, published research on training and development in organizations has actually decreased in top journals, leading some to observe that while an e-learning revolution is underway, the efforts of organizational scientists are largely focused elsewhere (Brown et al., 2012). Throughout this paper, I have highlighted opportunities for future research, summarized in Table 2. Because they have been explored above, I will not review them again here. I will, however, make a general comment about research on e-learning that I hope will spur organizational scientists to redouble their efforts in this exciting area.

A note about e-learning research. As of the time of this writing (early 2019), the vast majority of published academic articles on the effectiveness of digital training (gamification, web-based instruction, and so on) have been conducted in the educational – not organizational – domain (Brown et al., 2012; Committee on How People Learn II, 2018). This research typically compares web-based and classroom-based instruction using samples of students enrolled in college credits as part of their normal curricula. Although useful in understanding the potential of e-learning, this approach is obviously limited in its generalizability to working samples and organizational contexts. College students are usually engaged in fifteen-week courses that are more or less relevant to their major area of study; workers are usually engaged in shorter-duration training programs to learn a specific skill. Ideally, research on training in organizations would be conducted using workers who are randomly assigned to an e-learning intervention (versus an in-person/classroom control) with a pre- and post-test assessment of a performance dependent variable. In reality however, most studies of training effectiveness published in organizational science tend to use college student or convenience (e.g., Mturk) samples who, even if they are randomly assigned to condition, are not necessarily interested in training content and may or may not be representative of working adults in terms of abilities and skills.

Table 2. *An e-learning research agenda.*

Topic	Research Need
Implementation of the e-learning techniques in Table 1.	Although there has been research on the effect of web-based learning, blended learning, and MOOCs on learning outcomes, there is sparse research on other e-learning approaches listed in Table 1. Research should be conducted with an eye on the types of jobs that will be available in the future and demographic shifts in the workforce (i.e., the aging workforce).
Examine the social context of learning.	E-learning potentially makes learning an individual (versus group) activity. Although social learning theory describes the importance of learning from others, important social aspects of classroom training (connecting, commiserating, networking), have not been explored in meaningful ways.
The impact of games on learning goals and outcomes.	Games may represent an exciting e-learning approach, but research suggests that competition – a central element of games – may not facilitate learning. Research can explore the impact of games on learning versus achievement goal orientation and related performance outcomes.
Crowdsourcing feedback.	Can the social aspects of the internet (or company intranet) be exploited to provide learners constructive feedback? Crowdsourcing feedback may be particularly relevant for interpersonal skills training.
Mobile devices and micro-learning.	The proliferation of mobile devices shows no sign of stopping. How can e-learning be designed to take advantage of the ubiquity of smart devices? Micro-learning modules are a promising avenue for exploring the usefulness of mobile learning. However, the distractibility inherent in these devices is a consideration.
In-house or outsourcing.	The expense associated with developing quality e-learning modules will require resources that many organizations don't have. Outsourcing training that has typically been developed in house may impact the specialization and quality of training and an organization's ability to attract top talent.
Artificial intelligence (AI) and training.	Although artificial intelligence provides a means to customize training to the individual needs of the learner and to unobtrusively assess the effectiveness of training interventions, the effect of biases codified through AI and the impact of perceptions of surveillance on organizational culture are currently unknown.
Informal versus formal training.	E-learning will make it easier for workers to engage in ad hoc on the job training, which has not been well studied by organizational scientists. E-learning also promises the ability to unobtrusively examine the effects of informal learning and can potentially reinvigorate research on autonomous learning.

In the future, however, a rigid approach to research design that requires random assignment and pre- and post-tests of a performance outcome will become increasingly difficult. In particular, it is difficult to develop non-e-learning control conditions that engage the same affordances as the e-learning approaches described above. For example, consider a micro-learning intervention comprised of a five minute adaptive and interactive training intervention in which a person can engage anywhere at any time. What are potential control conditions? One possibility is engaging a human instructor to follow the trainee around all day to present the training when the trainee has downtime (e.g., at the coffee shop or swim meet). This example may seem ridiculous, but it is meant to demonstrate that strict adherence to standard approaches to training assessment may not be feasible in the future. Organizational scientists are going to have to become more creative about identifying and manipulating the psychological processes at play in different e-learning conditions and designing experiments that manipulate those mechanisms rather than trying to replicate technological affordances in non-digital delivery approaches. The bottom line is that organizations are embracing e-learning and digital approaches for training and development, many of which have not been properly researched or vetted. If organizational scientists want to influence the quality of digital training, we will need to move quickly.

Even though some digital training approaches may not be easily amenable to experimental examination, aspects of the technology may make the assessment of training outcomes easier in the long run. The same mechanisms that promote automatic feedback in e-learning can also be employed to assess the effectiveness of these approaches. That is, technology provides a mechanism to automatically assess what people have learned. Intelligent agents installed on desktops back on the job, or on mobile devices can provide information about whether trained tools are in use. These data can then be linked back to organizational goals to provide information about the return on investment in training that has heretofore been outside of the reach of training practitioners and scientists. Thinking forward, organizational scientists need to engage in meaningful research on all of these issues – from the effectiveness of different types of e-learning described above to employee reactions to unobtrusive assessments – to help organizations make well-informed decisions about how they should invest in the development of the future workforce.

Conclusion

It is exciting to think about the ways in which technology will impact training and learning in educational and organizational settings into the next century. Which of the training approaches described above will prove valuable over the long term? Which are merely passing fads? By engaging in well-worn instructional-systems design methods for developing training programs (i.e., designing pedagogy around training content and then considering the best tools to implement the pedagogical approach) organizations can maximize their investment in e-learning. Mapping the affordances associated with training technology listed at the beginning of this paper to pedagogical needs, and then deciding which e-learning technique best matches those affordances is a great way to start. The bottom line is – no matter how flashy and sexy the technology – if it is not deployed in service to a pedagogical strategy, it is doomed to fail. The role of organizational scientists is to assist organizations and learners in making smart decisions about e-learning through the empirical study of current and future e-learning approaches. There is much work to be done, but the future of e-learning is bright indeed.

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