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Current Issues and Future Directions in Simulation-Based Training

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Abstract

A number of emerging challenges including globalization, economic pressures, and the changing nature of work have combined to create a business environment that demands innovative, flexible training solutions. Simulations are a promising tool for creating more realistic, experiential learning environments to meet these challenges. Unfortunately, the current literature on simulation-based training paints a mixed picture as to the effectiveness of simulations as training tools, with most of the previous research focusing on the specific technologies used in simulation design and little theory-based research focusing on the instructional capabilities or learning processes underlying these technologies. This article examines the promise and perils of simulation-based training, reviews research that has examined the effectiveness of simulations as training tools, identifies pressing research needs, and presents an agenda for future theory-driven research aimed at addressing those needs.

Current Issues and Future Directions in Simulation-Based Training

The complexity and dynamicity of the current business environment increasingly requires employees to possess competencies that are not only specialized but also flexible enough to be adapted to changing circumstances. Research suggests that to develop this adaptive expertise, trainees should be active participants in the learning process and learning should occur in a meaningful or relevant context (Bell & Kozlowski, in press; Cannon-Bowers & Bowers, in press; Moreno & Mayer, 2005). Recent advances in technology have positioned simulations as a powerful tool for creating more realistic, experiential learning environments and thereby helping organizations meet these emerging training challenges (Bell & Kozlowski, 2007). The result has been an increased prevalence of simulation-based training in both academia and industry. Faria (1998), for example, found that 97.5% of business schools used simulation games in their curricula. Faria and Nulsen (1996) estimated that 75% of US organizations with more than 1,000 employees were using business simulations, and it has been estimated that in 2003 the corporate simulation-based training industry was between $623 and $712 million globally (Summers, 2004).

The increased prevalence of simulations is due, in part, to the many potential benefits they offer as a training medium. Like other types of distributed learning systems, simulations allow training to occur almost anywhere and anytime, and this flexibility can be used to reduce or eliminate many of the variable costs associated with traditional training, such as classrooms and instructors (Summers, 2004). Simulations also possess unique features that create the potential for instructional benefits not offered by other instructional mediums. For example, simulations can be used to create a synthetic- or micro-world that immerses trainees in a realistic experience and exposes them to important contextual characteristics of the domain (Schiflett, Elliott, Salas, & Coovert, 2004). Simulations can also be used as realistic practice environments for tasks that are too dangerous to be practiced in the real world or to provide opportunities for practice on tasks that occur infrequently (Cannon-Bowers & Bowers, in press).

Despite their vast potential, there are a number of costs and challenges associated with utilizing simulations to deliver training. One challenge is that the fixed costs associated with developing simulations are high and can be prohibitive for smaller organizations with limited training budgets. For example, it has been estimated that simulations delivered via e-learning can require 750 to 1,500 hours of development for each hour of training (Chapman, 2004). Perhaps a more important challenge is that research on the effectiveness of simulation-based training has produced mixed results with several studies failing to reveal an advantage for simulations (Cannon-Bowers & Bowers, in press). This suggests that more work is needed to fully realize the potential of training simulations, yet instructional designers are left with little guidance on how to develop an effective system because the factors that influence the effectiveness of simulation-based training remain unclear. These challenges may explain why, despite their growth, simulations represent a relatively small percentage (approximately 2-3%) of the total e-learning industry (Summers, 2004). In sum, as Ruben (1999, p. 503) states, “As much as computers, the Internet, distance learning, and other new teaching and learning technologies and tools have great promise, they are clearly not panaceas.”

Our goal in this article is to identify pressing research needs in the field of simulation-based training and present an agenda for future research aimed at addressing these needs. We begin by defining simulation-based training and related concepts, such as gaming. We then examine the benefits and challenges associated with simulation-based training. We aim to highlight both the promise of simulation-based training as well as the barriers that can prevent this promise from being realized. We then discuss the current state of research in the field of simulation-based training, focusing attention on key findings and research gaps. Finally, we conclude by presenting an agenda for future research aimed at addressing these gaps.

Simulation-Based Training Defined

Simulations are generally defined as artificial environments that are carefully created to manage individuals' experiences of reality. For instance, Jones (1998, p. 329) defines a simulation as an exercise involving "reality of function in a simulated environment." Cannon-Bowers and Bowers (in press) note that an essential feature of simulations and other synthetic learning environments (e.g., virtual reality) is, "the ability to augment, replace, create, and/or manage a learner's actual experience with the world by providing realistic content and embedded instructional features." Although not all simulations utilize technology (e.g., board games, role-plays), our focus in the current article is computer-based simulations because of their growing use and the pressing need for research on their effectiveness.

There are a number of constructs that conceptually overlap with simulations. For instance, *games* represent a specific type of simulation that features competitive engagement, adherence to a set of rules, and a scoring system (Cannon-Bowers & Bowers, in press; Teach, 1990). Thavikulwat (2004) notes that games and simulations are terms that are used relatively interchangeably (e.g., simulation-based games). Also, *virtual worlds* represent very elaborate simulations that allow for interactions among multiple players as well as between players and objects in the world (Cannon-Bowers & Bowers, in press). In the current article we use the term simulation-based training to refer broadly to all types of computer-based simulations that are used create synthetic learning environments.

Benefits of Simulation-Based Training

A number of emerging challenges, including globalization, economic pressures, the changing nature of work, and work-life issues, have combined to create a business environment that demands innovative, flexible training solutions (Bell & Kozlowski, 2007). Technological advances have served to position technology-based training applications as practical tools for addressing these challenges (Summers, 2004). Technological advances have expanded both the breadth and depth of training technologies (Salas, Kosarzycki, Burke, Fiore, & Stone, 2002), and today's high-end technologies offer the capability to provide information-rich content and immerse trainees in high fidelity, dynamic simulations. This focus on technology is evident in the simulation-based training literature as many studies have focused on either describing the technological features of simulations (e.g., Summers, 2004) or on describing specific training systems and applications (e.g., Draiger & Schenk, 2004).

In their recent review of synthetic learning environments, Cannon-Bowers and Bowers (in press) are critical of studies that have focused on specific technological training systems. They argue that focusing on the training system, with all of its embedded assumptions, strategies, features, and variables, makes it impossible to determine the underlying mechanisms or causes of outcomes. As they state, "… all that can be concluded is that this particular system did (or did not) work, but it is unclear exactly why" (Cannon-Bowers & Bowers, in press, p. 9). As an alternative, Kozlowski and Bell (2007) suggest looking past the technologies per se and instead focusing on the instructional features embedded within the technologies. Their approach links instructional goals of varying complexity to the instructional characteristics necessary to engage trainees' learning processes to achieve those goals. Therefore, although simulation research has typically focused first on the technology, Kozlowski and Bell's (2007) framework treats technology choice as the end-point of the training design process. In their typology they highlight four key categories of distributed learning system features – content, immersion, interactivity, and communication – that can be delivered by distributed learning technologies (e.g., CD-ROM, simulations) and used to create a desired instructional experience. Within these categories, specific technology features are organized from low to high with respect to the richness of the information or experience they can create for trainees. A better understanding of the instructional capabilities of different technologies can aid instructional designers and trainers in developing or selecting effective systems to meet specific training objectives. Table 1 summarizes the distributed learning features of simulation-based training and their associated instructional benefits, and we discuss each of the features in more detail the following sections.

Content. The first instructional feature discussed by Kozlowski and Bell (2007) is content, which concerns the richness with which basic declarative information is delivered through the system to trainees. As Schreiber (1998) notes, the presentation of information represents one of the key features of an instructional event. Text is the simplest means of conveying training content, although it is relatively low in information richness. To enhance the richness of the learning experience, additional features, such as still images/graphics, video, sound, and special effects can be added to the information stream.

Training simulations typically utilize an array of multimedia features to convey information through different sensory modes (e.g., images, sound) and to create a realistic and relevant context (Cannon-Bowers & Bowers, in press; Mayer, 2001). For example, simulations are now incorporating video game quality graphics and many offer a suite of supplementary multimedia learning materials (e.g., case studies, reference materials, tutorials, videos) on a CD-ROM or online (Summers, 2004). Stories and narratives are also increasingly being used to spark learners' interest, foster greater effort, and help guide the learner through the simulated experience (Cannon-Bowers & Bowers, in press; Fiore, Johnston, & McDaniel, 2007). In addition, the content covered by simulations is becoming increasingly specialized, with new applications focusing on topics such as customer service, supply chain management, and consultative selling. It is important, however, to recognize that more or richer information does not necessarily facilitate better learning (Brown & Ford, 2002). The key is selecting a mode of information presentation that will optimize learner's ability to understand and make sense out of the material (Mayer & Anderson, 1992). For example, when training basic declarative knowledge, multimedia features such as videos, graphics, and sound, may be no more effective

Table 1
Instructional Features and Potential Benefits of Simulation-Based Training

Information Richness	*Distributed Learning System Features*	*Specific Instructional Benefits of Simulation-Based Training*	*Relevant Technologies Employed in Simulation Design*
Low ↕ **High**	**Content:** Text Still images/graphics Images in motion Sound: voice, music, special effects	• Simulations typically include several multi-media features which can optimize learner's ability to make sense of material	• Video-game quality graphics • Supplementary training materials online or in CDROM (e.g., case studies) • Stories/narratives • Customized content
Low ↕ **High**	**Immersion** Psychological fidelity Constructive forces Stimulus space or scope Fidelity of context/ops Motion and action Real time Adaptive to trainees	• Prompt psychological processes relevant to performance in real-world settings. • Enable emotional arousal. • Knowledge integration. • Enhance feelings of presence and engagement. • Safe practice environment	• Real-time interactions • Motion and action • Realism of environment
Low ↕ **High**	**Interactivity** Single participants Individual oriented Multiple participants Team oriented	• Simulations have potential to offer high degree of interactivity with other users or the system • Use of characters or agents to simulate competitors, colleagues, or customers	• Decision trees • Virtual agents • Pre-programmed • Artificial intelligence
Low ↕ **High**	**Communication** One- way communications Two-way communications Asynchronous communications Synchronous communications Audio only Audio & video	• At high bandwidth trainees can interact in real-time. • Communication with the system	• Natural language processing. • Voice recognition technology.

than simple text, cost considerably more, are less user friendly, and may extend training time. However, for more complex and adaptive skills, the multimedia content offered by simulations may be critical to creating a meaningful learning experience (Kozlowski & Bell, 2007).

Immersion. The second category discussed by Kozlowski and Bell (2007) focuses on features that influence immersion, or sense of realism. At the low end, features are used to construct a synthetic representation of the task environment that offers psychological fidelity of constructs, processes, and performance. The goal here is not to replicate the actual performance environment, but rather to prompt the essential underlying psychological processes relevant to key performance characteristics in the real-world setting (Kozlowski & DeShon, 2004). Higher levels of immersion, such as that found in simulations, have the potential to enhance learners' feelings of presence, or the perception of actually being in a particular environment (Steele-Johnson & Hyde, 1997). High fidelity features, such as three-dimensional representation of content and motion/action, offer physical fidelity, which immerses trainees in a realistic experience and exposes them to important environmental characteristics (Schiflett et al., 2004). At high levels of immersion, the system can also react to trainee inputs, creating a symbiotic relationship between the user and the technology. In essence, psychological fidelity provides a basic foundation for learning, and physical fidelity offers the contextual richness that embeds important cues and contingencies into the instructional experience (Kozlowski & DeShon, 2004).

Arguably the greatest benefit of simulations is their ability to immerse trainees into an experience by creating a micro- or synthetic world that captures their attention and exposes them to important contextual characteristics relevant to the performance domain (Schiflett et al., 2004). The high level of immersion possible with simulations may help engage learners and stimulate greater effort, particularly among younger students (15-24 year olds) who have grown up on the Internet and expect rich, interactive, and even "playful" learning environments

(Proserpio & Gioia, 2007). Simulations can also immerse trainees in practice environments that may be too dangerous in the real world, allow trainees to practice when actual equipment cannot be employed, or expose trainees to situations that occur infrequently in reality. Perhaps more importantly, the experiential learning environment created by simulations is critical for enabling trainees to experience emotional arousal during performance episodes, develop an understanding of the relationships among the different components of the system, and also integrate new information with their existing knowledge (Cannon-Bowers & Bowers, in press; Keys & Wolfe, 1990; Zantow, Knowlton, & Sharp, 2005). As Katz (1999, p. 332-333) states:

> "The elegance of business simulations is instantly evident to anyone facing a classroom of twenty-five 20-year-olds who possess almost no direct business experience, but are still expected to walk away with a feel for the impact of their decision-making, the historic element of business, the presence of real competition, and the role of dumb, blind luck."

Interactivity. The third category, *interactivity* or collaboration potential, captures characteristics that can influence the potential degree and type of interaction between users of the system, between trainers and trainees, and, potentially, between teams or collaborative learning groups (Kozlowski & Bell, 2007). The extent to which the technology system can support rich interactions among these parties is directly contingent on the communication network, which is discussed below. However, interactivity is itself an important design consideration. It captures an important structural element of training - the level at which the training is offered (e.g., individual, dyadic, team). Given the spatial and sometimes temporal separation of learners in distributed learning, the issue here concerns the degree to which learners are "connected" during training or participate in training in relative isolation (Collis & Smith, 1997). In addition, interactivity is critical for ensuring the realism of team or collaborative performance contexts (Kozlowski & Bell, 2003; Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995). The technology must offer a level of information richness capable of supporting the high degree of interactivity inherent in collaborative learning and performance environments (Salas et al., 2002).

Training simulations have the potential to offer a high degree of interactivity. Simulation-based games allow trainees to compete against one another and understand how to adapt their decisions to the interactive effects of the environment and multiple competitors (Anderson, 2005). Increasingly simulations are enhancing the level of interactivity through the use of characters and virtual agents that simulate competitors, colleagues, or customers. As an example of the use of characters in simulation-based training, a customer service simulation may present the trainee with several customers who have questions about the store's merchandise (Summers, 2004). Based on a pre-programmed decision tree, the learner's interaction with the customer characters determines their responses. The trainee learns customer service skills by iterating through a series of decision situations and responses. As compared to characters, virtual agents are not guided by a predesigned structure (e.g., decision tree) but rather have the ability to determine their own behavior. A virtual agent possesses properties that determine its state and has artificial intelligence that determines its behavior given its internal state and external inputs from the environment. Thus, the interaction between the agent and the learner is free in form and evolves as they respond to one another. Although virtual agents are more sophisticated than characters, there is no academic research that compares the effectiveness of agent-based simulations and decision-tree simulations, nor is there research that compares the effectiveness of these new technologies to more traditional behavioral simulations (Summers, 2004). Thus, the utility of using these features to increase the level of interactivity and enhance learning outcomes is currently unknown.

Communication. Finally, it is important to consider features that influence *communication* richness or bandwidth, which determines the extent to which users can communicate via verbal and non-verbal means. One advantage of conventional instruction is that it collocates trainers and learners, which allows for face-to-face interaction among these parties. This enables the expert trainer to evaluate learners' progress in real time and provide necessary feedback and guidance. It also allows rich interaction and information sharing among learners. In distributed learning, however, communication channels, if available, are often degraded. Distributed learning systems often rely on asynchronous (i.e., temporally lagged) communication and limit communication to text or audio, which prevent dynamic interaction and the transfer of non-verbal cues. When rich interaction is critical for information sharing, providing instructional support, or creating realistic collaborative performance environments, communication bandwidth represents an important consideration in the design of distributed learning systems (e.g., Faux & Black-Hughes, 2000; Huff, 2000; Kozlowski & Bell, 2007; Meisel & Marx, 1999; Wisher & Curnow, 1999).

Advanced training simulations, such as the distributed mission training (DMT) systems used by the military, incorporate 2-way, synchronous communication to allow individuals and teams to interact in real-time (Kozlowski & Bell, 2007). In addition, advances have been made in terms of learner's communication with the simulation system itself. In the past, learners typically communicated with the system by selecting statements from multiple-choice lists. However, some simulations now utilize natural language processing (NLP) technology which allows users to communicate with the simulation by typing a sentence. An extension of NLP is voice recognition technology (VRT), which allows verbal communication with the simulation. This technology is increasingly being used in telemarketing and selling simulations (Summers, 2004). Nonetheless, as we discuss in more detail below, observers have noted that the richness of the human experience offered by simulations has not kept pace with advances in technology and programming (Katz, 1999). Further, although discussion boards, chatrooms, and other communication tools are often incorporated into simulation-based training to enhance interactivity, some evidence suggests these tools are often underutilized (Proserpio & Gioia, 2007). Overall, although simulations often possess the capability to allow significant communication bandwidth, it appears that capability is not yet being fully realized.

Challenges of Simulation-Based Training

Despite the practical and instructional benefits of simulation-based training, there also exist a number of costs and challenges associated with using simulations to deliver training. Some of the key challenges surrounding simulations involve managing development costs, leveraging higher levels of learner control, understanding individual differences, and shaping the unique social environment inherent in simulations. Table 2 summarizes these challenges, and in the following sections we discuss each in more detail.

Managing development costs. In the past, computer-based simulations were often delivered via seminars or in classroom settings, which meant that organizations incurred a number of indirect training costs associated with facilitators, classroom facilities, employee travel, and missed work (Summers, 2004). However, new and expanded technologies (e.g., Internet, broadband) allow simulations to be delivered to any computer and allow learners to engage in the experience when they wish. A benefit of this learning on demand model is that it greatly reduces or eliminates many of the variable and indirect costs associated with training delivery, thereby increasing the return on investment possible from simulation-based training. Indeed, estimates suggest that a substantial portion of training costs – upwards of 80% - is devoted to simply getting trainees to the training site, maintaining them while there, and absorbing their lost productivity (Kozlowski, Toney, Mullins, Weissbein, Brown, & Bell, 2001).

Nonetheless, the fixed costs associated with simulation development remain relatively high. For example, whereas traditional e-learning requires an average of 220 hours of development for each hour of content, estimates suggest that simulations delivered via the Internet require 750 to 1,500 hours of development for each hour of simulation (Chapman, 2004; Summers, 2004). Simulations that incorporate artificial intelligence or other advanced features

Table 2
Costs and Challenges Associated with Simulation-Based Training

Challenge	*Summary of challenge*	*Implications for learning*	*Industry trends*	*Research needs*
Managing development costs	Simulation-based training has large fixed costs.	Simulations are underutilized in practice, especially for smaller businesses.	"Canned" simulations are becoming more easily customizable which can reduce fixed costs.	Understanding key elements of design that must be customized.
Leveraging learner control	Greater learner control places responsibility for learning decisions on the trainee.	Learners do not accurately assess their current knowledge levels and often make poor learning decisions.	On-demand models are making learner control more pervasive.	Effects of incorporating guidance and support in simulation design
Understanding individual differences	Simulations often do not consider individual differences in learning styles.	A one-size fits all approach results in less-effective training designs.	A one-size fits all model is still the dominant industry model.	Examining which individual differences are important and understanding how simulations can be adapted to learners.
Shaping the social environment	Social interaction is considered a key element for learning but simulations often fail to take advantage of possibilities.	Feedback, sense of learning community are lacking in solitary simulation designs.	Communication technologies are being incorporated more frequently in simulations.	Understand how social environment and technology jointly shape instructional experience.

can require significantly more development work. The result is that for many organizations training simulations are only practical if these development costs can be amortized by delivering the course to a large number of trainees. Fortunately, the simulation industry has recently been moving towards ways to reduce fixed costs through the use of more efficient customization. Previously organizations had to choose between custom-made simulations and off-the-shelf products. Custom-made simulations were very expensive and only the largest companies could afford them. However, advances in object-oriented design and software libraries now enable suppliers to more easily customize their off-the-shelf simulations to fit customers' specific needs and also make it easier for an organization to reuse content across multiple courses (Summers, 2004). The result is greater specialization and flexibility at lower costs.

Leveraging learner control. As training simulations are increasingly delivered on-demand, trainees are being asked to engage in learning without direct involvement of an instructor or teacher. The result is trainees are being given greater control over their own learning. As Summers (2004, p. 228) states, "Learners must make time for learning and apply themselves without the benefit of a class, mandatory homework, or other motivational pressures." In addition, learners must manage their learning process, including monitoring and evaluating their progress and using that information to make effective learning decisions, such as what and how much to study and practice. Research suggests that learner control can yield several benefits. For instance, it enables motivated learners to customize the learning environment to increase their mastery of the content domain (Kraiger & Jerden, 2007). In addition, learner control can induce active learning and allow learners to generate relationships among new concepts and their existing knowledge (Reid, Zhang, & Chen, 2003; Zantow et al., 2005).

Despite its potential benefits, greater learner control is an important challenge facing simulation-based training designs. Specifically, significant research suggests that individuals often do not make effective use of the control provided by technology-based training (Bell & Kozlowski, 2002a; DeRouin, Fritzsche, & Salas, 2004; Reeves, 1993). Trainees often do not accurately assess their current knowledge level, do not devote enough effort to training, and make poor decisions, such as terminating study and practice early and skipping over important learning opportunities, resulting in deficiencies in performance (Brown, 2001; Ely & Sitzmann, 2007). As Blake and Scanlon (2007, p. 2) state, these findings suggest, "Simulations do not work on their own, there needs to be some structuring of the students' interactions with the simulation to increase effectiveness." Indeed, a number of recent studies have shown that adaptive advice and various types of support can help guide individuals through simulations and enhance learning outcomes (Bell & Kozlowski, 2002a; Leutner, 1993; Moreno & Mayer, 2005; Reid et al., 2003; Reiber, Tzeng, & Tribble, 2004). However, as we discuss later, additional research is needed to better understand the amount and type of guidance needed for trainees to leverage the learner control inherent in simulation-based training.

Understanding individual differences. In recent years, there has been a growing recognition of the powerful influence that individual differences in ability, prior experience, and disposition (i.e., personality) can have on how trainees approach, interpret, and respond to training. Moreover, it has been suggested that individual differences may be especially critical in technology-based training environments. Brown (2001, p. 276), for example, argues, "In computer-based training, the learner generally does not experience the external pressures of a live instructor and of peers completing the same activities. Thus, individual differences should be critical determinants of training effectiveness." Accordingly, it is important to understand how various individual differences interact with the design of simulations to influence overall effectiveness. DeRouin et al. (2004) suggest that trainees who are high in ability, prior experience, and motivation may benefit the most from the learner control offered by many experiential training simulations. High ability trainees, for instance, have sufficient cognitive resources to allow them to focus attention on learning activities, such as monitoring their learning progress and developing effective learning strategies, without detracting from their acquisition of important knowledge and skills (Kanfer & Ackerman, 1989). Similarly, prior achievement or knowledge in the content domain may help reduce cognitive load, thereby allowing trainees to better integrate new concepts and make effective learning decisions (Lee, Plass, & Homer, 2006).

Some emerging research suggests that there may also be specific individual differences that relate to trainees' aptitude or preference for simulation-based training. Anderson (2005), for instance, suggests that individuals' prior computer experience and ability to use technology may serve as antecedents to a positive experience with a training simulation. There is also some research that suggests that males and females may behave differently online, with males tending to exhibit more assertive and adversarial computer-mediated communication than females (Prinsen, Volman, & Terwel, 2007). Further, Summers (2004, p. 228) states, "Some people prefer mentored instruction while others prefer group-problem solving exercises. Still others prefer self-paced learning. Simulation products currently do not address this diversity of learning styles." The fact that most simulation products do not consider possible individual differences in learners means that only a portion of trainees may benefit from a particular application. Instructional designers need to be careful to avoid a "one size fits all" approach to simulation design, and research is needed to better understand the individual differences that are important in simulation-based training and methods to accommodate the needs of different trainees (Bell & Kozlowski, 2007).

Shaping the social environment. The final challenge facing organizations concerns the unique social environment that often results from simulation-based training design. There are many who believe that the classroom atmosphere, interactions among trainees and between trainees and trainers, and sense of learning community offered by traditional, face-to-face instruction are essential for learning (Webster & Hackley, 1997). Katz (1999, p. 335), for instance, argues, “The real distinctive competence of the classroom setting is the power of the people around you – the professor as facilitator and expert, the peers as sources of immediate feedback ….” A high level of interactivity is not necessary for all training programs, but when it is important to learning or for giving employees an opportunity to socialize and network with their colleagues, the challenge is determining how to most effectively connect learners using communication and collaboration tools (Bell & Kozlowski, 2007).

Although the social context is often an important part of the learning process, many simulations continue to offer a solitary learning experience, which can jeopardize the advantages of social interaction and collaboration in training. Fortunately, there is a growing use of communication technologies that enable trainees to engage in virtual social exchanges that approximate face-to-face interactions. In particular, as organizations increasingly offer simulation-based training through the Internet, it is becoming easier and cheaper to network trainees and incorporate communication and collaboration tools (Katz, 1999). However, research also suggests that just because the tools or capabilities are offered, that does not necessarily mean they will be used. There is some evidence to suggest that groupware tools, such as web-based forums and chatrooms, often used to supplement traditional classroom activities are generally underutilized by students (Prosperio & Gioia, 2007). These findings suggest that trainees may only utilize communication and collaboration tools when they are essential to the simulation experience.

Evidence for the Effectiveness of Simulation-Based Training

In the preceding sections we examined both the benefits and challenges associated with simulation-based training. Our discussion highlights the fact that although training simulations possess considerable instructional potential, there are also many challenges and barriers that organizations face to realizing this potential. Thus, an important question concerns whether, in practice, the benefits of simulations generally outweigh the challenges and limitations. Put more simply, are simulations generally an effective training method? In this section we provide a brief review of research that has sought to answer this question. In addition, we examine the current state of research in this area and highlight several limitations of prior studies of the effectiveness of simulation-based training.

A growing body of literature suggests that simulations can serve as effective training tools. Washbush and Gosen (2001), for example, identified a total of 11 well-designed experimental studies of business simulations and concluded that the use of simulations improved learning by an average of 10% on pre- and post-training knowledge assessments. Wolfe (1997) included quasi-experimental studies in his review, but reached a similar conclusion that simulation gaming produced better learning than the use of business case studies. In their recent review of synthetic learning environments, Cannon-Bowers and Bowers (in press) note that simulations have been shown to be effective in a variety of contexts, including the training of pilots, clinicians, military personnel, fireman, and survey interviewers. A number of studies have also shown that in addition to enhancing learning outcomes, individuals generally report positive reactions (e.g., satisfaction) to the use of simulations in training and education (e.g., Mitchell, 2004; Romme, 2004).

However, it is important to recognize that the evidence for the effectiveness of simulations is far from conclusive. First, some observers have suggested that the extant research is not extensive enough to firmly conclude simulations are effective, due to a shortage of rigorously conducted studies (Tonks & Armitage, 1997). Keys and Wofe (1990, p. 311), for example, stated, "… many of the claims and counterclaims for the teaching power of business games rest on anecdotal material or inadequate or poorly implemented research designs." Unfortunately, a recent review by Gosen and Washbush (2004), conducted over a decade later, reached a similar conclusion. Second, although there exists significant support for simulation-based training, a number of studies have *failed* to find an advantage for simulations (e.g., Cameron & Dwyer, 2005; Ellis, Marcus, & Taylor, 2005; Thomas & Hooper, 1991).

A closer examination of prior research in this area highlights several specific issues that limit the extent to which we can draw valid conclusions regarding the effectiveness of simulation-based training. First, a large number of the studies on simulation effectiveness have been conducted in K-12 or college settings (Moreno & Mayer, 2004; Vogel, Greenwood-Erickson, Cannon-Bowers, & Bowers, 2006). While these studies provide important information regarding the effectiveness of simulations for educating children and young adults, one needs to exercise caution in using these findings to endorse the use of simulations for training employees in business settings. Additional research is needed to examine the effectiveness of simulations for training adults on topics relevant to business contexts (e.g., customer service, management, change management).

A second limitation of prior research concerns the outcomes used to measure the effectiveness of simulations. Due to the prevalence of studies conducted in school settings, prior research has focused largely on the effects of simulations on self-reported learning or tests of knowledge (Wideman, Owston, Brown, Kushniruk, Ho, & Pitts, 2007). However, several researchers have suggested that because simulations promote experiential, discovery learning, they may create knowledge that is more implicit than explicit and, therefore, difficult to measure using traditional knowledge tests. Swaak and de Jong (2001), for example, used a series of five experiments to compare the effects of simulations on several measures of implicit knowledge and more traditional declarative knowledge. Their results revealed a positive effect of simulation-based training on the implicit knowledge measures, but no effect on the more traditional knowledge measures. Similarly, Thomas and Hooper (1991) have argued that the implicit knowledge developed by simulations may be better revealed through tests of transfer and application, which unfortunately are rarely included in studies of simulation-based training effectiveness. Thus, future research is needed to examine the effects of simulation-based training on a broader range of outcomes, including transfer, adaptability, and other more implicit or tacit measures of knowledge (Swaak & de Jong, 2001).

A final limitation of prior research concerns the fact that very few studies have examined the learning processes through which simulations impact important learning outcomes. Scherpereel (2005), for instance, notes that although business simulations are designed to help participants think differently, there has been little empirical research examining the effects of simulations on trainees' mental models. Wideman et al. (2007) similarly note that research on educational gaming has done very little to illuminate the cognitive practices and learning strategies that students employ when playing a game. A focus on learning processes is critical for determining the underlying mechanisms or causes of the outcomes of simulation-based training (Cannon-Bowers & Bowers, in press). As Wideman et al (2007, p. 17) state:

> "An understanding of game play and its relationships to the cognitive processes it evokes in users is essential for answering the question of how games succeed or fail, and it plays a critical part in untangling the complex relationships between various game attributes, the learning process, and learning outcomes."

Future Research Directions

As discussed above, prior research suggests that simulation-based training is often effective, yet several studies have failed to reveal a positive effect of simulations on learning outcomes. Importantly, the extant research in this area has provided limited insight into the factors that underlie or influence the effectiveness of simulation-based training. The result, as Salas and Cannon-Bowers (2001: 483) state, is that "Theoretically-based research is needed to uncover principles and guidelines that can aid instructional designers in building sound distance training." In this final section we highlight several issues that may serve as fruitful avenues of future inquiry.

Understanding the instructional capabilities of simulations. Clark (1983, p. 445) states, "The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition." His argument, which remains true today, is that technology is only a means of delivering training content and, as such, has no direct influence on learning. Yet, simulations possess unique instructional capabilities that have the *potential* to enhance training effectiveness. To realize this potential it is important to understand how the instructional capabilities of simulations – in the areas of content, immersion, interactivity, and communication – can be leveraged to deliver the instructional experiences necessary to accomplish different types of training objectives.

The theoretical framework presented by Kozlowski and Bell (2007) represents a preliminary attempt to link the instructional features of various distributed learning technologies to the types of instructional experiences they support. As noted earlier, this framework moves beyond a focus on technological systems and focuses instead on the instructional capabilities of the underlying technological features. One contribution of this approach is that it provides greater insight into the technological components that influence learning in distributed environments. Further, this approach can aid instructional designers and trainers in developing or selecting a training system that integrates the technology components essential to achieve desired learning outcomes. In this article, we have used this theoretical framework to examine the distributed learning system features of simulations and their associated instructional benefits. As we have noted, however, research on the instructional capabilities of simulations is limited and, therefore, future application-oriented work is needed to examine the ability of simulations to offer specific levels of richness on the various distributed learning features. This work can also serve as the foundation for research aimed at better understanding how the features of simulations can and should be used to accomplish different types of training objectives. For example, it is important to understand those situations in which high levels of communication richness are critical to simulation-based training effectiveness. Similarly, research needs to provide guidance regarding the level of immersion necessary for achieving different types of training goals (Leung, 2003). As Moreno and Mayer (2004, p. 172) state, "… there is no need to waste costly resources on developing high-immersion virtual reality learning environments if high immersion does not directly serve the educational objective of the lesson."

Cannon-Bowers and Bowers (in press) also highlight the need for future research on the instructional capabilities of simulations. In particular, they focus attention on the six categories of instructional events discussed by Sugrue and Clark (2000), such as providing appropriate practice environments, and identify research issues in each of these areas that need to be addressed to optimize the design of synthetic learning environments. For example, they suggest that examples, narratives, and stories may represent effective means of providing information and enhancing learners' engagement and feelings of presence, but research is needed to determine how best to incorporate these strategies into the simulation environment (also see Fiore et al., 2007). In addition, they argue that research is needed to understand what degree of authenticity (i.e., cognitive and emotional fidelity) is required to support learning and to determine what factors contribute to an authentic experience. In summary, the research agenda specified by Cannon-Bowers and Bowers (in press) further highlights the need to better understand how the instructional capabilities of simulations can be used to shape trainee's learning experience.

Adopting a process-based research approach. In addition to examining the impact of different features of simulations on important learning outcomes, future research needs to provide insight into the processes or mechanisms that explain these effects. As noted earlier, very little of the research in this area has adopted a process-based approach, which limits our ability to understand why a particular simulation was or was not effective (Cannon-Bowers &

Bowers, in press; Scherpereel, 2005). Recent research by Bell and Kozlowski (in press) suggests that active or experiential learning approaches impact learning and performance through three relatively distinct process pathways. The first pathway is cognitive in nature and concerns how trainees focus their attention during learning. For example, metacognitive activities, such as planning and monitoring behavior, have been identified as critical for enabling learners to successfully orchestrate their own learning (Bransford, Brown, & Cocking, 1999). The second pathway focuses on important motivational processes, such as goal orientation, intrinsic motivation, and self-efficacy. These processes influence the orientation (e.g., focus on learning or performance) individuals take toward a training task, the amount of effort they devote to learning, and the extent to which they persist through challenges and failure (Bell & Kozlowski, in press). The final pathway focuses on the extent to which trainees use self-regulatory processes to control their emotions during training. Since active learning can often be a difficult or stressful process, it is important for trainees to control negative emotions, such as anxiety or frustration, so that they can focus their attention and effort on learning (Kanfer, Ackerman, & Heggestad, 1996).

Future research should incorporate measures of these cognitive, motivational, and emotion processes to gain greater insight into the mechanisms through which simulation-based training impacts learning and performance. For example, it has been argued that immersing trainees in realistic learning environments may help enhance their interest and spur greater effort, yet very little research has directly tested this proposition. Further, research has shown that the quality (e.g., coherence) of trainees' knowledge structures is an important predictor of adaptive performance (Kozlowski, Gully, Brown, Salas, Smith, & Nason, 2001). Yet, the effect of simulation-based learning on trainees' information processing and mental models has received very little research attention (Scherpereel, 2005; Wideman et al., 2007). Research that empirically establishes linkages between the features of training simulations and various learning processes can help trainers and instructional designers develop systems that create the instructional experience needed to achieve desired training objectives (Kozlowski & Bell, 2007).

Identifying effective support and guidance strategies. As organizations increasingly adopt an on-demand model for delivering simulation-based training, it is important to identify effective guidance and support strategies that can be embedded in the design of simulation-based training. In particular, it is important to understand how much and what type of support trainees need to leverage the learner control offered by simulation learning environments. Reid et al. (2003), for instance, argue that learners need three types of support in simulations that provide them with an exploratory or discovery learning environment. The first is interpretive support, which helps learners analyze the problem and activate relevant, prior knowledge. The second, experimental support, helps learners engage in meaningful discovery learning activities. In particular, experimental support scaffolds learners in the systematic design of experiments, prediction and observation of outcomes, and the drawing of reasonable conclusions. Finally, reflective support increases learners' self-awareness of the discovery processes and helps them integrate the discovered rules and principles. Reid et al. (2003) conduct an experiment to examine the effects of interpretive and experimental support, and provide evidence that these strategies can help learners make meaning of the discovery experience and enhance the effectiveness of simulation-based training. However, this study was conducted with 8th graders learning physics principles, so future work is needed to examine the generalizability of these strategies to other learner populations and training content.

A number of recent studies have also examined the effects of supplementing distributed learning with different forms of guidance. Bell and Kozlowski (2002a), for example, provided learners in a simulation-based training environment with adaptive guidance, which provided diagnostic feedback and personalized study and practice recommendations based on trainees' performance improvement across practice sessions. The results of this study showed that adaptive guidance had a positive effect on the nature of trainees' study and practice, quality of their self-regulatory processes, knowledge acquired, performance, and performance adaptation. Moreno and Mayer (2005) examined the effects of guidance in an agent-based multimedia game. In their study, the guidance was in the form of explanatory feedback, which explained to students why a particular answer to a problem is correct. Their results revealed that guidance did not enhance knowledge retention, but did lead to greater near and far transfer. In addition, students who received guidance also gave more correct explanations for their answers, suggesting greater comprehension of the learning content. Although this research suggests that guidance may be a useful strategy for enhancing learning in simulation-based training environments, future research is needed to determine the type of guidance that is most effective and how to embed guidance naturally into simulations so that it is not disruptive (Cannon-Bowers & Bowers, in press).

Adopting a learner-centered perspective. It is important to recognize that even the most well designed training simulation will not be effective for all trainees. As we discussed earlier, there exist a number of individual differences that have the potential to moderate the effectiveness of simulation-based training. However, very little research has examined how individual differences interact with simulation design to influence overall effectiveness, which makes it difficult to determine for whom simulation-based training is most effective or how to adapt the design of such systems to different types of trainees. Future research needs to adopt a learner-centered perspective so as to identify those individual differences that are relevant to simulation learning environments. Prior research conducted in more traditional training environments suggests that cognitive ability, prior experience, and motivation may be important determinants of trainees' ability to leverage the learner control inherent in simulation-based training (DeRouin et al.., 2004).

Cognitive ability and motivational dispositions have also been shown to be important individual differences in simulation-based training research. For example, Bell and Kozlowski (in press) showed that cognitive ability interacted with instruction (exploratory learning versus proceduralized instruction) such that learners with higher cognitive ability benefited more from exploratory learning – with its greater degree of learner control – by evidencing greater metacognition. In addition, goal orientation dispositions (learning, performance-prove, and performance-avoid) interacted with error framing (instructions to make or avoid errors) to influence motivational states. There is also evidence that cognitive ability and goal orientation dispositions interact to influence self-regulatory processes and performance in simulation-based training (Bell & Kozlowski, 2002b), so these individual differences are fertile areas for further research. However, it is also important to recognize that there may be individual differences that are unique to simulation-based training environments. For example, there is evidence to suggest that some people are more likely than others to experience immersion (Kaber, Draper, & Usher, 2002), suggesting that there may be individual differences in the extent to which people benefit from immersive environments in training (Cannon-Bowers & Bowers, in press).

In addition to identifying relevant individual differences, it will be important for future research to identify strategies that can facilitate learning among those individuals who may otherwise fail to benefit from simulation-based training. Guidance, for example, may help trainees with little or no prior experience in a domain make effective use of learner control and may also be an important supplement for trainees with less well developed self-regulatory skills. In addition to guidance, optimizing cognitive load in visual displays of computer simulations may help some trainees more than others. Lee et al. (2006), for example, found that combining symbolic and iconic representations of information increased comprehension and transfer for students with low prior knowledge, but not students with high prior knowledge. They suggest that the use of multiple representations may have had a greater load-reducing effect for trainees with low prior knowledge of the domain. Although these appear to be promising strategies, future research is needed to better understand how simulations can be adapted to the strengths and weaknesses of different trainees, their preferences, and their learning progress.

Conclusion

Simulations have great potential as a medium to create highly-relevant training contexts where trainees are active participants in the learning process. Realizing the benefits of simulations is a critical topic for both research and practice, as businesses increasingly demand effective training solutions that create specialized and adaptive knowledge and skills. For simulations to realize their potential, however, future research is needed to address the critical theoretical issues we highlighted in this article. The framework that we presented categorized the instructional features of simulations and linked them to specific instructional capabilities. It is our hope that this framework will guide future research on simulations to operate from a more conceptually grounded perspective so the benefits of simulations may be fully realized.

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